LAOSA, A TYPICAL SOUTHERN ARIZONA RANCH.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 67.
B. T. GALLOWAY, *Chief of Bureau.*

RANGE INVESTIGATIONS IN ARIZONA.

BY

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GRASS AND FORAGE PLANT INVESTIGATIONS.

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GRASS AND FORAGE PLANT INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 1, 1904.

Sir: I have the honor to transmit herewith the manuscript of a paper on Range Investigations in Arizona, which embodies a report upon investigations conducted in cooperation with the experiment station of the University of Arizona.

The paper is a valuable contribution to our knowledge of improvement of range lands, and I respectfully recommend that it be issued as Bulletin No. 67 of the regular Bureau series.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The main features of the range problem have been reduced to two: The carrying capacity of the range, and the best methods of managing the range so as to secure the largest amount of feed from it without permanent injury to the food plants that furnish the covering of the soil. The principles of management may be reduced to the following: A proper control of the amount of stock upon a given range and the time of the year at which they are allowed upon the various subdivisions of it; the protection of such native plants as are of value, and, particularly, the saving of seeds of such plants and scattering them upon the range; lastly, the introduction upon the range of such new forage plants as experience has shown can be thus introduced.

A knowledge of the carrying capacity of the ranges is of the utmost importance, for it must form the basis of any intelligent legislation relating to the range question. This knowledge determines the rental and sale value of range lands and should also determine the size of the minimum lease or homestead for range purposes in case laws are passed providing for such disposal of the public ranges.

The present report includes a general study of range problems in southern Arizona, but is devoted more particularly to the investigations conducted in cooperation between the United States Department of Agriculture and the Arizona Experiment Station on two tracts of land situated on the Santa Rita Forest Reserve in the Territory of Arizona. The work upon one of these tracts, consisting of a fenced area of 58 square miles, has been conducted under the immediate supervision of Dr. David Griffiths, of this Office. The work upon the other area, which is also fenced and consists of some 240 acres of land, has been conducted under the supervision of Prof. R. H. Forbes, Director of the Arizona Experiment Station, by Prof. J. J. Thornbur of that station, since August, 1901. Previous to that time Doctor Griffiths was a member of the station staff at Tucson, and conducted the work on the small tract also. Once each year the Department has furnished the Arizona Experiment Station with a report of the work done by its officers upon the large tract, while the officers of the station have furnished to the Department a similar report of the work on the small tract. Particular attention is called to the study of the amount of

vegetation produced upon the large tract since it was fenced nearly two years ago. It will be noted that deductions concerning the carrying capacity of this range made from this study agree in a most satisfactory manner with actual practice. It is proposed in the near future to determine by actual trial the amount of stock this fenced area will carry without deteriorating.

Acknowledgments are due to Mr. Howell Jones, of the Santa Fe railway system, for much assistance in prosecuting the investigations reported in this bulletin.

W. J. Spillman, *Agrostologist.*

Office of Grass and Forage Plant Investigations,
Washington, D. C., June 29, 1904.

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RANGE INVESTIGATIONS IN ARIZONA.

INTRODUCTION.

The discussions of the following pages are based upon experimental work and observations made in the Territory of Arizona between the months of August, 1900, and November, 1903, in cooperation with the Arizona Experiment Station. The experimental work thus far has been conducted upon the small inclosure near Tucson, a discussion of which was the main feature of Bulletin 4 of this series. Such data regarding this work as were not included in that publication are discussed here. The opportunities of the writer for observation of the conditions obtaining throughout the main grazing areas have been very good, especially during a residence of an academic year at Tucson in 1900–1901 and during the spring, summer, and autumn of 1903.

Besides visiting the region within 60 miles of Tucson at all seasons of the year, the following list of trips over the different portions of the range country is appended for the purpose of fixing more definitely the time at which these observations were made, as well as to make the data accompanying the rather large collections of forage and other plants secured upon these several journeys and afterwards deposited in various herbaria more complete:

October 6 to 19, 1900. Tucson to Wilcox via Benson, and return via Pearce and Tombstone.

December 6 to 23, 1900. Maricopa to Tempe, and return to Picacho via Mesa and Florence.

March 17 to 22, 1903. Tucson to Laosa via Sopori and Arivaca, and return via Babuquivari Mountains and Robles.

March 24 to 30, 1903. Tucson to Dudleyville via Willow Spring Mountains, and return via San Pedro and across the Rincon Mountains to Tanque Verde.

April 7 to 15, 1903. Tucson to Nogales, and return to Phoenix via Arivaca, Coyote, Santa Rosa, and Casagrande.

May 15 to 18, 1903. Williams to Bright Angel and return.

June 29 to July 8, 1903. Huachuca Mountains to Cannanea, Sonora, Mexico.

July 16 to 17, 1903. Prescott to Mayer.

July 18 to 19, 1903. Ash Fork and Williams.

July 20 to 23, 1903. Flagstaff and south to Mogollon Mountains.

July 25 to 26, 1903. Winslow and Holbrook.

August 8 to 17, 1903. Adamana to Fort Apache via Long H ranch and St. Johns, returning via Showlow.

September 12 to 22, 1903. Adamana to Chin Lee, and return via Navajo.
September 24 to 25, 1903. Prescott to Mayer.
October 6 to 11, 1903. Tucson to Patagonia via Greaterville and Cottonwood, and return via Sopori, Arivaca, Babuquivari Mountains, and Robles.

This rather formal list takes no cognizance of the work done between trains and on short stops at various places along the lines of railroad, especially on the main line of the Santa Fe system, the Santa Fe, Prescott and Phoenix, and the Santa Fe, Prescott and Eastern railways, between Needles and Gallup and between Phoenix and Ash Fork.

Arizona has a total area of 72,332,800 acres, of which only 254,521 acres are improved; but there are reserved 19,724,717 acres, according to Governor Brodie's report to the Secretary of the Interior in 1902. A part of this reserve land is available for grazing purposes under certain restrictions, grazing being allowed upon all the forest reserves excepting the Grand Canyon, and of course the Indians raise a great deal of stock upon their reservations. Taking everything into consideration, there are probably upward of 65,000,000 acres available for stock raising.

According to the Twelfth Census (1900), there were in the Territory 1,033,634 units of stock, sheep and goats being calculated at the rate of 6 to 1 bovine animal in relation to pasture consumption. Unfortunately no distinction was made in these Census reports between range and farm stock, so that it is impossible to determine from the lists the number of stock supported on native pastures. All that can be said is that there was in the Territory in 1900 one animal unit to approximately every 65 acres of land available for stock purposes. This includes farm animals as well as range stock. It is interesting to compare these figures with those given by Mr. C. W. Gordon in the statistics of the Tenth Census. Here Mr. Gordon, who made an elaborate report upon the conditions, as well as the number of animals, estimated that in 1880 there were 229,062 units of stock, occupying 43,750 square miles of range lands, or 1 unit to 122.24 acres.

THE SMALL INCLOSURE.

A full description of the small inclosure was given in Bulletin No. 4 of this series, after the first planting was made in the winter of 1901. It will not be necessary, therefore, to enter into the details of the work on this area any further than to discuss briefly the results which have been secured by the experiments which were suggested at that time, and which have been carried on since with such modifications and changes as further light and experience have shown to be necessary.

As stated in Bulletin No. 4, some sixty species of forage plants were sown, the work being begun on the 10th and finished on the 23d of January, 1901. These plants were given various forms of treatment, the seed of some being covered by a disk harrow and of others

by a smoothing harrow; in some cases the ground was harrowed or disked before planting, and in others the seed was sown on the uncultivated mesa. Besides the seed sown, *Lippia repens*, recommended as a soil binder for arid situations, was planted on one of the embankments. This plant is still living and has covered the spaces between the hills in a few places; but it can hardly be considered promising for situations which do not receive more rainfall than these mesas. Plantings of this species subsequently made have failed entirely.

The vast majority of the plantings of grasses made the first year were a failure from the start; that is, the seed did not germinate at all. There were some good rains following closely upon the completion of the seeding, furnishing ideal conditions for the germination of such grasses and other forage plants as are adapted to the prevailing conditions at that season. The following are the mean temperatures for the early months of 1901 at the university, 5 miles distant: January, 51° F.; February, 52° F.; March, 55.6° F.; April, 61.7° F.

As will be seen from an examination of the lists published in Bulletin No. 4 of the Bureau of Plant Industry, some of the seed planted was from the Northwestern States, but the greater part of it was native seed gathered the previous autumn. A considerable quantity which might be considered native was nevertheless from a very different situation from that in which it was planted upon the mesas surrounding Tucson. As examples may be mentioned the seed secured in Sulphur Spring Valley, Arizona, and in Silver City, N. Mex., all of which grew at high elevations. A comparison of the northern and southern seed during the two following months was very interesting indeed. It was the seed from the northwest which gave promise of success during February and early March. Several species from the north germinated remarkably well, while the vast majority of the native species did nothing, as was to be expected, for they make their growth during the hot, moist weather from July to September. To this general rule, however, there were some marked exceptions. *Boutelona oligostachya*, for instance, germinated well and there was a good stand of it on plots 43 and 69 in March. Upon these plots native seed was sown, but it was secured from an altitude of about 5,000 feet. Seed of this species received from the north did not germinate, possibly owing to its being old or poorly matured. Many of the native species which did nothing upon the range germinated in the grass garden a few days later in the season, as discussed in the text and tables given below. Rescue grass (*Bromus unioloides*) purchased from seedsmen and of unknown origin germinated well enough to make a good stand had it been able to combat the drought of spring and early summer. It would have succeeded much better, no doubt, if it had been planted in early autumn.

The following tabular statement in connection with Bulletin No. 4

will serve to emphasize the fact that it was the northern-grown seed which germinated to best advantage upon the range plots during the cool weather of spring:

Record of germination upon range plots, spring of 1901.

Name of plant.	Number of plot.[a]	Origin of the seed.	Date of germination.	Condition.
Agropyron spicatum	6	Walla Walla, Wash	Feb. 9	Good stand.
Agropyron occidentale	7 and 68	do	do	Thin stand.
Atriplex canescens	33	Tucson, Ariz	Mar. 4	Good stand.
Atriplex halimoides	40	California	Mar. 8	Very thin stand.
Atriplex semibaccata	43	do	Feb. 9	Good stand.
Bouteloua oligostachya	43 and 69	Cochise, Ariz	Mar. 8	Do.
Elymus canadensis	61	Silver City, N. Mex	do	Thin stand.
Elymus ambiguus ?	63	Walla Walla, Wash	Feb. 21	Very thin stand.
Elymus condensatus	64	Washington	Mar. 8	Thin stand.
Elymus virginicus submuticus.	65	Walla Walla, Wash	do	Very thin stand.
Agropyron tenerum	66	do	do	Thin stand.
Agropyron spicatum	67	do	Feb. 9	Good stand.
Bromus polyanthus paniculatus.	74	Silver City, N. Mex	Mar. 8	Do.
Phleum asperum	75	Walla Walla, Wash	do	Do.

[a] For information as to the location of the plots and methods of culture, see Bul. No. 4, Bureau of Plant Industry, 1901.

Shortly after completing the seeding on the range plots, a small grass garden was established on the university campus in rather a protected place behind the main building. This was designed for purely scientific study, but it served nevertheless as a very instructive check upon the species planted on the range. The planting was done here on the 13th and 14th of February and the plots were irrigated by well water when they needed it. The saltbushes were planted in a plot by themselves at some distance from the building, and consequently in a more exposed place.

The following tabular statement lists all the plants sown upon the range which germinated under irrigation and did not do so under the natural mesa conditions. The two tables, therefore, include all species, the seed of which was of known origin, planted on the mesa, which germinated in the spring; but the last table does not give a complete record of the grass-garden germinations, for there were many things planted in the grass garden that were not at hand in sufficient quantity to be sown upon the mesa:

Record of germination upon irrigated grass garden, spring of 1901.

Name.	Number of plot.[a]	Date of germination.	Source of seed.	Condition.
Sporobolus cryptandrus	6	Nov. 15	Tucson, Ariz	Thin stand.
Sporobolus wrightii	7	Mar. 4	do	Good stand.
Chloris elegans	11	Mar. 22	do	Very thin stand.
Muhlenbergia gracilis	13	Mar. 4	Cochise, Ariz	Thin stand.
Hilaria cenchroides	17	Mar 22	New Mexico	Very thin stand.
Poa fendleriana	31	Mar. 15	Silver City, N. Mex	Good stand.
Phaseolus retusus	38	Mar. 22	New Mexico	Do.
Andropogon saccharoides	39	Mar. 6	Cochise, Ariz	Thin stand.
Bouteloua rothrockii[b]	40	Apr. 13	do	Very thin stand.
Atriplex lentiformis	62	Mar. 15	Tempe, Ariz	Thin stand.
Atriplex polycarpa	69	do	do	Do.

[a] These are numbers of plots in the grass garden and have no reference to previously published numbers.

[b] This was incorrectly called *B. polystachya* in Bul. No. 4 of the Bureau of Plant Industry in referring to plots 26, 31, and 70. Throughout that publication these two species were not segregated.

By the middle of May there was nothing which had been planted upon the range plots alive, except a little *Lippia repens*, which had been placed upon one of the embankments thrown up across an old roadway, and a few scattered plants of shad scale (*Atriplex canescens*) on area F. Everything else had succumbed to the drought which invariably prevails in this region from March to June.

During the rainy season of the following August several plants which were sown in the winter germinated and made some growth. The most conspicuous of these was Metcalfe's bean (*Phaseolus retusus*), which germinated and grew beautifully through August, but died out completely by the middle of September. *Andropogon saccharoides* and *Chloris elegans* made a very small growth, but nothing commensurate with the quantity of seed sown and the labor involved.

During the autumn of 1903 there was nothing to show for the plantings of 1901 except a few stray plants of *Andropogon saccharoides* in the southeastern corner of the field, a similar growth of shad scale on portions of area F, and a small strip of *Lippia repens* on one of the embankments. None of these, however, gave promise of success.

In June, 1901, the writer discontinued his connection with the Arizona Experiment Station to accept his present position in the United States Department of Agriculture. The work upon the small tract was placed under the immediate supervision of Prof. J. J. Thornbur, of that station. During the summer of 1902 cooperative arrangements were entered into by the Department of Agriculture and the Arizona station whereby the investigations on the small tract were to be continued and those upon the large tract, discussed later, were to be instituted. Since that time Professor Thornbur has had charge of the work upon the small tract and the writer that upon the large tract.

The following paragraphs relating to the work upon the small tract are based upon data obtained from reports furnished this office by Professor Thornbur.

Since the winter of 1900–1901 considerable work has been performed on this area in an attempt to conserve storm waters by the erection of embankments and by the introduction of forage plants which will thrive under the advantages afforded by the dams. It is believed that the perennial plants which have been sown thus far can not be successfully established upon these mesas without careful attention to the soil and conservation of the waters, both of which entail considerable expense.

The dams built were thrown up across the water courses as in the winter of 1901, but their forms have been slightly changed because it was found that the diversion of the water did not suffice to spread it out very much nor to check its flow sufficiently to allow it to penetrate the ground as much as necessary. This is especially true with reference to the summer rains. The precipitation during the winter months, although causing considerable run-off, is much more gentle and penetrates the ground more readily.

The work done thus far seems to indicate that the most efficient dam for a gently sloping mesa is one which is so constructed that it will spill around the ends when the water has reached a height of not more than 12 inches. This requirement demands that the dam be constructed nearly on contour lines,[a] except at the ends, which are turned so as to retain water up to the desired depth and spread it over as much ground as possible. Besides the two dams mentioned in Bulletin No. 4, seven additional ones were built in January, 1902. These vary in length from 270 to 600 feet and in height from 12 to 24 inches, and are built at an average cost of a little more than $13.

In January, 1902, some seeding was done, but only in favored places, mostly above the embankments. Fewer species were planted than the previous year, and only two made any growth at all. Egyptian clover (*Trifolium alexandrinum*) and *Panicum texanum* were sown in the same dam, the first in the lower situation. The Egyptian clover germinated beautifully early in August, but all died in a very short time. *Panicum texanum* produced only a few plants, which made no seed.

Besides the above, seeds of the following species were planted: *Hilaria mutica*, *Bouteloua rothrockii*, *Atriplex coronata*, *A. elegans*, *A. nuttallii*, *A. canescens*, *A. bracteosa*, *A. polycarpa*, *A. nummularia*, *A. halimoides*, *A. leptocarpa*, *A. semibaccata*, *A. eremicola*, *Rhagodia inermis*, and *R. linifolia*. No seedlings of any of these species were observed.

During the last week in June, 1903, a third seeding was done. As in the second operation, the seed was sown in the vicinity of the dams

[a] This form of dam was first suggested by Prof. S. M. Woodward.

and the ground was prepared to receive it. In some cases, however, seed was sown below the dams, as well as above them. The following species were planted: *Panicum texanum*, *Andropogon saccharoides*, *Bouteloua curtipendula*, *B. rothrockii*, *B. oligostachya*, *B. hirsuta*, *B. aristidoides*, *Eriochloa punctata*, *Sporobolus wrightii*, *S. stricta*, *S. cryptandrus*, *Phaseolus retusus*, *Astragalus nuttallianus*, *Chætochloa composita*, *Pappophorum apertum*, *Chloris elegans*, *Elymus glabrifolius*, *Epicampes rigens*, and *Leptochloa dubia*.

In all cases the seed was sown very thick. Had all grown, the plants would have been entirely too numerous upon the ground. In many cases four times as much seed was sown as would produce a good stand if it all grew. Experience has shown that a good deal of the native seed is of very low germinating quality, and must often be sown excessively thick in order to even approximate a stand.

Many of the seeds of plants sown this time made considerable growth, but only in two or three cases was there anything like a stand secured. *Andropogon saccharoides*, *Bouteloua curtipendula*, *B. oligostachya*, *B. hirsuta*, and *Leptochloa dubia* all made thin stands. *Bouteloua rothrockii* made a scattering growth in one situation and quite a fair stand in another, but nowhere was there a better stand where it was sown than on favorable situations upon the uncultivated and undisturbed mesa in the immediate vicinity. The best stands and the best growth were secured with *Panicum texanum* and *Chloris elegans*. The former was especially good in places, but very uneven on account of having been sown partially in the depressions in the dams where the surface soil had been removed for the construction of the embankments and partially upon ordinary weathered soil. The lower depressions doubtless held water a little too long after the summer rains for the best development of the grass. In one of the dams there was considerably less than one-half acre which would cut at the rate of 1 ton of dry feed per acre. There was about a quarter of an acre of *Chloris elegans* in one of the dams which would yield at the rate of one-fourth ton of dry feed per acre. *Panicum texanum* has yielded by far the most promising results of anything tried thus far. It is an annual, however, and can not be used except in some such way as the common cultivated millets. There is little doubt that this grass is capable of considerable application in forage-plant culture in this region. If the seed could be secured at reasonable prices it might be sown upon barley fields for the production of summer and fall grazing and possibly for a small crop of hay in October. It matured this year in about ninety days after being sown.

The behavior of some of the native grasses was very interesting this year, especially when considered from the standpoint of seed habits. Usually perennial grasses do not mature much seed the year they are planted. The case is very different with species from this region. Some of them, although distinctly perennial in habit,

mature seed in abundance in three months after being sown. This was especially the case with *Andropogon saccharoides*, *Bouteloua hirsuta*, and *B. oligostachya*, and less conspicuously true of *B. curtipendula*. *Bouteloua rothrockii* and *Leptochloa dubia* produced mature heads from practically every plant which grew. *Bouteloua rothrockii* produced fine, large bunches, with an abundance of mature seed. It should be noted that the latter is but a short-lived perennial at best. It is therefore not so surprising that it should produce an abundance of seed the first season. *Trichloris fasciculata* often produces two crops of seed—one in May and the other in September—in neglected spots and fence corners in the Salt River Valley.

THE LARGE INCLOSURE.

During the spring of 1903 arrangements were made for enlarging the work begun upon the mesas near Tucson in 1900. Permission having been granted by the Department of the Interior, an irregular tract of land upon the Santa Rita Forest Reserve, containing 49.2 square miles, or 31,488 acres, in the four townships Nos. 18 and 19, in ranges 14 and 15 east, Gila and Salt River meridian, was inclosed by a four-wire fence, completed early in June (fig. 1). Practically all stock was excluded from the tract by the 10th of June. This area differs very materially from the desert mesas upon which the small inclosure is situated, as will be seen from the descriptions given below. Much of it is situated within the altitude where perennial grasses are produced, and it is therefore capable of sustaining much more stock than the small inclosure upon the mesa.

TOPOGRAPHY.

The portion of the Santa Rita Forest Reserve which, after a preliminary survey, it was decided to fence is located in the northern foothills of the Santa Rita Mountains. It has a general northwesterly slope toward the Santa Cruz River (Pl. III, fig. 2). All of the region is well drained and there is consequently no accumulation of alkali at any point. Considerable quantities of water flow over portions of the area at certain seasons of the year. The presence of *Atriplex canescens* in the northwestern portion does not necessarily indicate that there are accumulations of soluble salts in the soil at this point.

The field, as a whole, contains typical foothill pasture lands of the region at this altitude. Along the eastern side there are rocky, steep bluffs rising 500 to 800 feet above the general level of the area. To the west and south of this point there are gently sloping areas free from brush. On the west half of the north side there occurs a considerable area of "washed country," while the east half of this side is a typical arid, creosote-bush area where no grass of any consequence ever grows. None of the higher mountain areas has been included on

account of the difficulty and expense of fencing. Neither are any bottom lands included, for none of the typical river bottoms lies within the reserve. The bluffs spoken of above, however, answer very well for the mountain area, for they have upon them some of the more valuable mountain grasses; but they possess the disadvantage of not

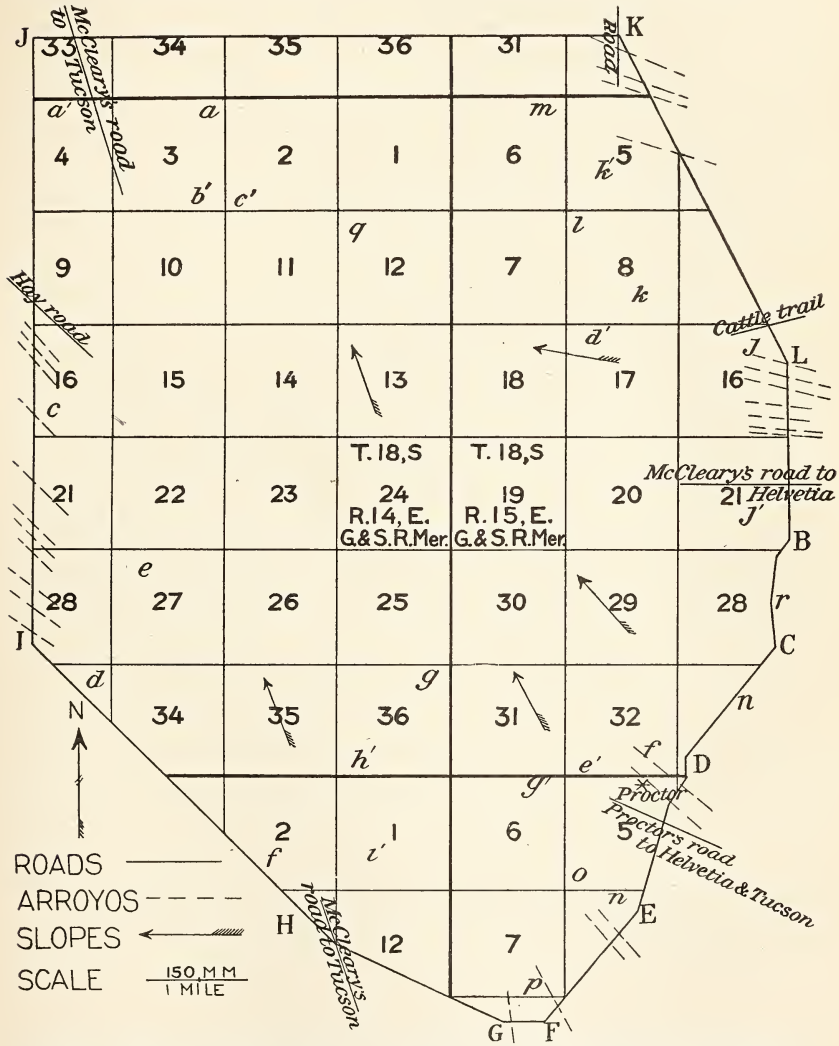

FIG. 1.—Diagram of the large inclosure in the northern foothills of the Santa Rita Mountains.

getting the rainfall of the higher mountains. It is to be regretted that no bottom land could have been fenced; but after all, in some respects, this would not be very much of an advantage, because the vacant river bottom lands in this vicinity are not, as a rule, productive, and do not figure at all conspicuously in the range feed supply.

The entire tract is more or less cut up by arroyos. These are usually steep, rugged, and rocky close to the mountains, but become wider and more shallow northward. The water which they carry during flood time is consequently spread over larger areas on the north side of the field. The surface water which goes down to the north side, however, is small in quantity and of short duration, but the sands of the arroyos carry an underground supply of water for several days after a rain. This supply of moisture to the shrubby vegetation is very considerable along these temporary water courses, but the areas between them receive only such moisture as happens to fall at those points. During the violent summer showers much of this runs off.

As stated above, the southern portion of the area is a comparatively open region, being cut by frequent arroyos, as indicated on fig. 1 between points L and G. The largest of these is the one which runs close to Proctor. At this point it is from 150 to 200 feet deep and 800 feet wide from bank to bank. Here the bottom of the arroyo is on solid rock, which accounts for the appearance of water at the surface. In general, however, it, like the others, is of coarse sand and like them widens out to the northward, its banks becoming lower and less rocky. Between the points L and B on fig. 1 on the fence line there are a number of small steep arroyos, and the same condition exists on the southern half of the west line, but the latter are less pronounced than the former. All of the arroyos are more rocky close to the mountains, and gradually spread out to the northwest, making the whole area a sloping plain, cut at frequent intervals by usually shallow washes to the northward and by deeper arroyos and canyons to the south. Besides the above water courses there are numerous gullies cut by the flood waters. These usually occur as laterals to the main arroyos, and extend into the broad gentle slopes which exist between the main water courses. The condition is a difficult one to portray, for the cuts are made by the flood waters, whose action is explained only when considered in connection with a surveyor's level and with the chemical and physical conditions of the soil. One can drive with a light rig over the entire field by picking his way slowly, but in many places he is obliged to travel considerable distances in order to get around the arroyos. This is especially true of the southern half of the field.

SOIL.

But little discussion of the subject of soil can or need be entered into. In general it may be said that the soil is of a light-brown color and composed of very fine particles intermixed with a large amount of coarse sand and gravel. On the south side it is much looser in texture, has more gravel in its composition, and packs less firmly upon drying than on the north side. On this account the sloping areas between the arroyos are not so badly washed, which condition, together with a

more abundant supply of moisture, accounts for the more luxuriant vegetation and evenly distributed grassy covering. On the whole the soil does not differ from that which obtains throughout the entire region in similar situations. The area is well drained, but the soil softens very much more upon being moistened than would be expected. It is true, however, that it is very seldom that the moisture penetrates to great depths. In October, 1902, it was with great difficulty that 1-inch stakes of redwood or Oregon pine could be driven into the ground to a depth of 6 inches with an ax, yet, when the heavy rains of November came, these fell down of their own weight and could be driven into the ground their entire length by the pressure of the hand.

When the fence was built a peculiar condition of soil was observed along the middle of the northern fence line. The post-hole work was purposely done at a time when the ground was wet, and consequently, easily dug over the greater portion of the tract. In the above locality, however, to our astonishment, a heavy rainfall had not penetrated more than 2 or 3 inches, although the soil received the drainage of the entire Box Canyon region. On the greater part of the fence line, however, the winter and spring rains had penetrated to a depth of 2 feet or more. This area is known here as "washed country," which simply signifies that the upper strata of sandy loam has been removed, leaving the very closely packed, nonabsorbent subsoil exposed.

Underlying portions of the ground is a deposit of caliche, a calcareous hardpan, of variable thickness. All the arroyos, canyons, and washes are covered with a clean, coarse sand, while the steeper areas are coarse gravel and rocks. The soil particles are only slightly washed, as would be expected. Prof. W. P. Blake[a] considers the caliche to be derived from long-continued evaporations of subterranean waters raised by capillary action.

The soil of the general area is derived for the most part from the disintegration of the granitic rocks of the Santa Rita Mountain upheaval.

BRUSH AND TIMBER.

The greater part of the area is covered with a scattering growth of various shrubs and small trees. The northern and western portions contain much more shrubbery than the southern and eastern parts. A line drawn from corner L to corner I, figure 1, represents approximately the dividing line between the heavier and lighter brush. Upon the southern half there are large stretches which have practically no brush at all. Along the washes and arroyos, however, there are invariably found numerous shrubs, some of which attain to the dignity of trees, although very scraggy. A close examination of the broad,

[a] Transactions American Institute of Mining Engineers, Richmond meeting, February, 1901.

gentle, grassy slopes between the arroyos in this vicinity reveals a very scattering growth of mesquite (*Prosopis velutina*), which is in the form of twigs 2 to 3 feet high, with an occasional larger shrub in some of the more favorable localities. Without more critical data regarding the previous history of the region than it is possible to secure at the present time, one can not tell whether this growth indicates that this shrub is spreading or not. The present condition rather suggests this possibility. It would not be at all surprising, for there appears to be abundant evidence that such is the case under the influence of stock grazing in portions of Texas, where a closely related mesquite grows in abundance.

By far the most important shrub is the mesquite, which, like the majority of the other shrubs, is especially at home from the line LI, figure 1, northward and along the arroyos in the southern half of the inclosure. In many localities in the southern half cat-claw (*Acacia greggii*) is nearly as abundant as the mesquite at the present time. This, however, is better protected than the mesquite, and the wood choppers have generally avoided it on this account. The other smaller species of acacia (*A. constricta*) is less abundant, but is also confined to the arroyos. The blue palo verde (*Parkinsonia torreyana*), which rivals the mesquite in size, grows in similar localities. The desert willow (*Chilopsis linearis*), cottonwood (*Populus fremontii*), hackberry (*Celtis reticulata*), soapberry (*Sapindus marginatus*), and walnut (*Juglans californica*) grow sparingly in some of the upper canyons. A large part of the northwestern portion of the field is badly infested with *Isocoma coronopifolia*. The line LI, figure 1, passes through a very conspicuous growth of large bunches of *Ziziphus lycioides*, which is of as little value as the creosote bush (*Covillea tridentata*), which occupies some of the southeastern portion of the field. The greater part of the latter was avoided, however, in the final fencing, a very large area being found immediately north of the eastern portion of the inclosure. The upper edges of it are included in the northeastern portion of the field and in places along the northern portion of the McCleary road to Tucson. The line LI also represents the most profuse growth of the Cactaceæ, the main species of which are prickly pear (*Opuntia engelmanni*), cholla (*Opuntia fulgida*), and *Opuntia spinosior*. These, together with the sewarah (*Cereus giganteus*), are the most conspicuous of the cacti within the inclosure. The biznaga (*Echinocactus wislizeni*) occurs in scattering individuals over the entire tract.

Of the other cacti little need be said. *Opuntia arbuscula* grows scatteringly on the northern portion, while *Cereus fendleriana* and *C. greggii* are occasionally found in the same region. On the rocky banks and higher bluffs are numerous other inconspicuous species, such as *Mammillaria grahami*, *M. arizonica*, *Cereus rigidissimus*, and

C. caespitosus. Upon the higher elevations there are scattered plants of *Yucca baccata*, *Agave applanata*, and *A. schottii*, while *Yucca radiosa* is scattered along the northeastern fence line in rather limited numbers. *Nolina microcarpa* and *Dasylirion wheeleri* are conspicuous, especially on the northern slopes of the hills, while thickets of ocotilla (*Fouquiera splendens*) are frequent on the southern slopes. Scattered at rather frequent intervals all over the brushy area are to be found clumps of Brigham's tea (*Ephedra trifurca*). Besides these there are a great many other usually smaller shrubs scattered over various portions of the inclosure, some of them of considerable economic importance. They will be discussed under another head.

The area contains typical foothills, and does not differ materially from similar regions in the foothills of the Huachuca, Santa Catalina, and Babuquivari mountains in this same general region. As a rule, there are large, gently sloping, grassy areas comparatively free from brush between the brushy mesas and the sparsely timbered mountains, not only in southern Arizona, but in New Mexico as well.

FORAGE PLANTS.

This inclosed area contains three typical and natural subdivisions of the grazing lands of this portion of the Southwest, and the cattleman would look upon it as an average grazing proposition, not the best, nor yet by far the poorest. The first subdivision may be described as an arid desert mesa; the second, adjoining the first, may very properly be designated as open, gently sloping foothills, comparatively free from rocks; and the third, as rough, rocky bluffs and arroyo banks.

The arid mesa portion of the inclosure occupies approximately half of the field, and we may accept a line drawn from corner L to corner I, figure 1, as the division between this region and the open foothills. This division line would in all probability be more accurate if it were described as extending from L to a point about 1½ miles north of I on the west fence line. It will be seen that the upper edge of the heavy brush (*heavy* is used in a purely relative sense) corresponds roughly with the lower edge of the grassy area. North of this line there is but little grass, the main forage plants being various desert herbs and shrubs to be described later. In a favorable season there are areas of considerable magnitude of six weeks' grass (*Bouteloua aristidoides*) along the arroyos and on the higher levels of the west side, as far north as section 9, township 18, range 14; and there is usually more or less *Triodia pulchella* and six weeks' grass upon the rocky ridges in the northwest part of the pasture. These two grasses, however, are of little forage value here. They never, so far as experience since 1890 teaches, occur here except scatteringly. At times there are tufts of such perennial grasses as *Leptochloa dubia*, *Chætochloa composita*,

Andropogon saccharoides, and *Bouteloua rothrockii*, together with the annual *Bouteloua polystachya*.

By far the greater part of the feed here is produced by the winter and spring annuals and the browse plants. The first of these are mainly Indian wheat (*Plantago fastigiata*), *Pectocarya linearis*, *Sophia pinnata*, *S. incisa*, *Thelypodium lasiophyllum*, *Monolepis nuttalliana*, *Phacelia arizonica*, *Ellisia chrysanthemifolia*, *Sphærostigma chamænerioides*, and several species of Gilia and Linanthus. There are also extensive areas of *Atriplex elegans*, often growing to the exclusion of all else and producing from 200 to 500 or more pounds of dry herbage per acre. This plant, although an annual, usually germinates in the spring and matures in autumn, passing through the dry season in the vegetative state.

The list of shrubby plants which occur here and which are of more or less forage value is quite large. The majority of them have been mentioned under another heading. The mesquite is by far the most important. Cat-claw (*Acacia greggii*), *A. constricta*, *Parkinsonia torreyana*, and *Ephedra trifurca* are also abundant. *Baccharis brachyphylla*, *B. bigelovii*, and *Anisacanthus thurberi*, while common in the shrubby mesa region, are much more abundant along the arroyos in the southern half of the field. During late spring the annual groundsel (*Senecio longilobus*), is a very conspicuous plant upon portions of the lower areas, and purslane (*Portulaca retusa*), forms a loose cover in many places in the fall. The former is probably of no forage value, while the latter furnishes good feed. In places in autumn two other species of purslane (*P. stelliformis* and *P. pilosa*) are of some value on the east side of the field.

It is to the open foothills that the greatest interest attaches, for it is here that the perennial grasses become numerous enough to be reckoned with in the range ration. The six weeks' grama (*Bouteloua aristidoides*) is by far the most abundant grass over the greater portion of this area, being especially abundant in the *Ziziphus lycioides* areas in the neighborhood of the line LI, fig. 1. In the same locality are also to be found large quantities of *Aristida americana* and its variety *humboldtiana*, the latter being usually found surrounding ant hills. *Bouteloua rothrockii* makes a tall, thin stand on the better portions of the gently sloping stretches between the arroyos, where in favorable years it makes a very conspicuous growth, but can not be said ever to take possession, for mixed with it are invariably found much six-weeks' grama and *Aristida americana*. Growing in similar situations, and in some seasons covering large areas, are to be found *Bouteloua bromoides*, *B. eriopoda*, and *B. havardii*, which, however, are the main grasses on the majority of the rocky banks and bluffs along the arroyos. In the latter situations are also to be found *Andropogon contortus*, either in solid patches or scattering bunches, and *Andropogon saccha-*

roides at slightly lower levels. Confined mainly to the loose sands in the vicinity of the washes, but also at times extending over portions of the rocky hillsides, is a scattering growth of *Bouteloua vestita*, while *Muhlenbergia porteri*, the black grama of this region, is invariably limited to the protection of cat-claw and other spiny or thorny shrubs. The rough grama (*Bouteloua hirsuta*) is usually found upon all of the rocky banks, but it is at home in the higher bluffs and mountains beyond the inclosure. The same may be said of the side-oat grama (*Bouteloua curtipendula*). Growing under the protection of bushes along the arroyos in this section is always to be found more or less *Panicum lachnanthum*.

In the spring these open, grassy foothills are a veritable flower garden of magnificent proportions, so conspicuous in the neighborhood of section 24, township 18, range 15, as to be plainly visible from Tucson, a distance of from twenty-five to thirty miles away. The poppies (*Eschscholtzia mexicana*) in this place develop a little later than upon the mesa near Tucson or in the foothills of the Tucson Mountains. This is explained by the difference in altitude and exposure, and at times may be influenced by variation in rainfall as well, although the rainfall of the winter is more evenly distributed than that of the summer season. Other plants which are abundant enough to influence the vernal landscape by their floral colors are *Linanthus aurea*, *Phacelia arizonica*, *P. crenulata*, *Orthocarpus purpurascens palmeri*, *Baileya multiradiata*, *Lupinus leptophyllus*, *Eriophyllum lanosum*, and *Baeria gracilis*. None of these are altogether without forage value, although the poppies and one or two of the other species mentioned are not eaten when there are other plants of greater palatability. The other vernal vegetation consists of such small plants as "patota" (*Pectocarya linearis*), *Plagiobothrys arizonicus*, *Eremocarya micrantha*, *Lotus humistratus*, *L. humilis*, *Astragalus nuttallii*, Indian wheat (*Plantago fastigiata* and *P. ignota*), all of which are of forage value. To these should also be added covena (*Brodiæa capitata*) and the mustards (*Lesquerella gordonii*, *Sophia pinnata*, *S. incisa*, and *Thelypodium lasiophyllum*).

The spring grasses on the open foothills amount to little in the average season. The perennials mentioned above, especially the gramas, make a slight growth of root leaves in a favorable season, and *Aristida americana* sometimes develops to the point of seed production. *Festuca octoflora* is common throughout the area, but it is never abundant enough to make any feed. *Poa bigelovii* often furnishes quite a little grazing around the bases of bushes and in other protected areas in the arroyos, where *Chætochloa grisebachii* is of some value in the fall. In autumn there is usually considerable feed produced by lamb's-quarters (*Chenopodium fremontii*).

An enumeration of the main forage plants upon the rougher portion

of the inclosure has necessarily been made in the previous paragraphs. All of the perennial species mentioned above grow here in scattering clumps. Besides those mentioned, of which the gramas (*Bouteloua bromoides*, *B. eriopoda*, *B. curtipendula*, and *B. hirsuta*), *Andropogon saccharoides* and *A. contortus* are the most important, *Muhlenbergia vaseyana*, *Hilaria cenchroides*, *Aristida divergens*, *A. schiedeana*, *Eragrostis lugens*, *Chætochloa composita*, *Trachypogon montufari*, *Leptochloa dubia*, *Epicampes rigens*, together with a little *Hilaria mutica* in a few places, are of importance. *Panicum lachnanthum* usually grows under the protection of shrubs, as stated above, but it sometimes covers considerable areas of open land, as shown in Pl. II, fig. 2. In 1902 and 1903, *Pappophorum apertum* made a very conspicuous growth upon the top of Pyramid Hill, where it and *Nicotiana trigonophylla* were the only conspicuous plants.

The blue grama (*Bouteloua oligostachya*), although of great importance on the opposite side of the mountains, does not occur here, at least not in sufficient quantities to be of any consequence. The same is true of *Chloris elegans*.

A part of the forage upon the inclosure is produced by the Eriogonums, which are not distantly related botanically to the docks, one of which, the canaigre (*Rumex hymenosepalus*), is very common along all of the arroyos. The most important species is *Eriogonum microthecum*, which grows to best advantage on some of the rougher foothills of the regions south and west of Proctor. It makes its best development here upon the higher lands beyond the fence line. Many of the annual species are also grazed by stock, and *E. thurberi*, *E. trichopodium*, *E. cernuum*, *E. abertianum*, and *E. divaricatum* are abundant enough to influence the general aspect of portions of the field at certain seasons of the year. Besides the above species, *E. polycladon*, *E. thomasii*, *E. pharnaceoides*, and *E. watsoni* (?) are common in some localities. *Eriogonum trichopodium* is so abundant at times in the region between the bushy and open foothills and farther north as to give its characteristic yellow color to large areas of ground.

AMOUNT OF FEED PRODUCED.

It seems highly desirable to secure as accurate an estimate as possible of the amount of herbaceous feed produced upon this inclosure at the present time. This is desirable not only for an estimate of the amount of stock that can be carried upon these lands, but also as a basis for comparison as to the value of protection and systematic grazing when observations shall have been made and data secured upon such points. In view of this fact an attempt was made to secure at the most opportune times during the two vegetative seasons as accurate an estimate as possible of the amount of growth which occurred upon the inclosure during the seasons of 1903. The estimate was secured

by measuring the yield of all vegetation excepting the shrubs upon representative areas carefully selected from the different divisions of the tract. The positions of the plots measured are indicated by letters upon the diagram (fig. 1). A to Q represent those areas measured between the 1st and 20th of April, and A′ to K′ between the 29th of September and 2d of October, 1903.

It will be noticed that but few perennials, aside from the grasses included in the fall reckoning, are listed. It was the intention to estimate only the grasses and other annual plants, but it was decided after the work was begun to include a few perennial species other than the grasses. It might appear better to have made quantitative measurements upon those plants of forage value only; but it is exceedingly difficult to decide which species are and which are not forage plants. It often happens that nearly all plants that grow are eaten. What is grazed depends largely upon what is available for stock to eat within walking distance of water. It was deemed better, therefore, to measure the entire growth exclusive of the shrubbery, and to estimate the nonforage plants by deducting from the totals thus obtained such a percentage as seems justifiable, based upon personal observations as well as the testimony of stockmen.

In these measurements a unit area 3 feet by 7 feet was adopted, and in the majority of cases the areas were measured by a frame of the dimensions stated constructed for this purpose. In a few cases the areas were measured with a tapeline. All plants within the frame were pulled up, counted, cleaned, the roots cut off at the surface of the ground, and the plants thoroughly dried and subsequently weighed. In some instances where the number of plants was very large and the distribution uniform, one-half of the plot only was used for the estimate, although the tables given below are based upon areas of 3 feet by 7 feet for the sake of uniformity in tabulation. In four instances plants were discarded—that is, no records of them are made in these tables. They were so small and of such insignificant weight that they would amount to only about 1 pound per acre. The annotations in the last column of the tables mention these.

While making the measurements in the spring it was found that in some of the plots there was a number of very small seedlings which it was decided not to include at that time on account of the fact that they would necessarily have to be included in the autumnal measurements. This avoided counting the same plants twice. It was decided to include *Atriplex elegans* in both spring and autumnal measurements, because of the better growth made by it than by the others, and on account of the great loss which the plant would sustain during the long dry season from April to the first of July. This loss, it is thought, will in a large measure correct the error incurred by the double estimate of this plant. The measurements were made when it

was believed the maximum yield for the season would be secured. It was impossible, of course, to select a time when the maximum for each plant could be obtained on account of the difference in the date of maturity and the difference in the resistance to the drought of late spring.

Tabular statement of plot measurements.

[Each plot contains 21 square feet.]

Name of plant.	Number of plants.	Height of plants.	Condition of plants.	Weight.	Condition of plot.
PLOT A.		*Inches.*		*Grains.*	
Eschscholtzia mexicana	4	5	In bloom	26	A broad, nearly level area from which some surface soil has been removed by erosion. Sparsely covered with shrubbery.
Atriplex elegans	9	3	Very young	76	
Gilia floccosa	9	4	Under bloom	20	
Lotus humilis	1	2	In fruit	2	
Pectocarya linearis	10	2	do	104	
Sphærostigma chamæneri-oides.	4	5	In bloom	2	
Lepidium montanum	5	7	do	80	
Filago californica	1	1	do	3	
Triodia pulchella	1	2	do	2	
Phacelia arizonica	5	4	In fruit	28	
Lotus humistratus	4	2	In bloom	21	
Caucalis microcarpa	9	4	do	6	
PLOT B.					
Monolepis nuttalliana	57	3½	In fruit	1,631	A broad, shallow depression, from which nearly all brush has been cut and the surface soil removed by erosion.
Atriplex elegans	5	5	Very young	94	
Onagra trichocalyx	1	1	In bloom	10	
PLOT C.					
Filago californica	2	1½	In bloom	1	On a stony ridge in an area cut with steep, shallow ravines.
Lotus humistratus	1	1½	do	2	
Sphærostigma chamæneri-oides.	1	3½	do	4	
Gilia floccosa	1	3	Under bloom	2	
Eriogonum abertianum	4	3	In bloom	10	
PLOT D.					
Aristida americana	24	6	Under bloom	297	On the southern exposure of a stony knoll containing an unusually good growth of Aristida. Besides the list there are 223 seedling *Eriocarpum gracilis* less than 1 inch high.
Lupinus leptophyllus	3	5	Early bloom	56	
Lotus humistratus	20	2	In bloom	63	
PLOT E.					
Lotus humistratus	183	3 to 4	In fruit	555	A gently sloping, grassy area at the upper edge of the heavier mesquite brush. Besides the plants listed there are two small seedlings of *Gærtneria tenuifolia*, and ten plants of *Bouteloua rothrockii* beginning to grow.
Pectocarya linearis	116	2½	do	611	
Astragalus nuttallii	7	2 to 4	In bloom	11	
Plantago ignota	26	4	Early bloom	53	
Gilia floccosa	8	5	do	11	
Plagiobothrys sp	71	3 to 4	In fruit	469	
PLOT F.					
Plantago ignota	595	1 to 4	Early bloom	245	Very similar to E. No brush excepting an occasional mesquite from 2 to 3 feet in height. There is considerable old grass of *Bouteloua rothrockii*, *B. aristidoides*, and *Aristida americana* from last season.
Lotus humistratus	189	1	Full bloom	126	
Plagiobothrys arizonicus	35	6	Late bloom	147	
Pectocarya linearis	374	1 to 3	In fruit	318	
Orthocarpus purpurascens palmeri.	37	5	In bloom	93	
Gilia floccosa	38	2 to 3¼	Early bloom	56	

Tabular statement of plot measurements—Continued.

Name of plant.	Number of plants.	Height of plants.	Condition of plants.	Weight.	Condition of plot.
PLOT G.		*Inches.*		*Grains.*	
Plagiobothrys sp	14	4	In fruit	101	Differing but little from Plot F. Besides the plants listed there are 12 small seedlings of *Eriocarpum gracilis* to be included in the autumnal reckoning.
Lupinus concinnus	190	1 to 8	Early bloom	999	
Calandrinia menziesii	276	1½	In fruit	700	
Plagiobothrys arizonicus	17	3 to 12	do	116	
Lotus humistratus	94	1 to 1½	In bloom	56	
Baeria gracilis	53	3 to 4	Full bloom	53	
Linanthus aureus	4	3 to 4	do	2	
Plantago ignota	49	2 to 4	Under bloom	35	
Festuca octoflora	84	1½ to 4	do	14	
Filago californica	35	1 to 3	In bloom	14	
Phacelia arizonica	6	2	Early bloom	15	
Eremocarya micrantha	49	1 to 1½	In fruit	21	
PLOT H.					
Eriogonum thurberi	97	1 to 2	In bloom	77	In the bottom of Box Canyon, upon a coarse, sandy alluvium, which has not been disturbed for several years.
Eremocarya micrantha	21	1 to 2	do	8	
Lupinus leptophyllus	21	4 to 8	do	102	
PLOT I.					
Lotus humistratus	67	1 to 5	In fruit	56	Upon a stony, southern exposure bordering Box Canyon. Besides the plants listed there are 30 plants of perennial grasses just beginning to develop. *Opuntia engelmanni* is very conspicuous here.
Plantago ignota	38	1 to 3	Early bloom	57	
Erodium texanum	7	3	In fruit	78	
Eriophyllum lanosum	19	1 to 2	Full bloom	9	
Phacelia crenulata	10	2 to 6	In bloom	23	
Astragalus nuttallii	34	3	In fruit	259	
PLOT J.					
Eschscholtzia mexicana	343	1 to 9	In fruit	542½	Broad, open, gently sloping foothill region which produced a large crop of *Bouteloua aristidoides* last year.
Plantago ignota	291	1 to 2	Early bloom	70	
Lotus humistratus	32	(a)	Full bloom	101	
Eremocarya micrantha	115	1 to 2	do	14	
Erodium cicutarium	3	2	Early fruit	6	
Eriophyllum lanosum	5	1 to 2	Full bloom	4	
Stylocline micropodes	35	1 to 2	In bloom	7	
Pectocarya linearis	24	1 to 2	In fruit	5	
PLOT K.					
Pectocarya linearis	310	1 to 4	In fruit	878	On a rocky hillside among steep, stony, bare arroyos. *Zizyphus lycioides* is conspicuous here. *Bouteloua aristidoides* was the chief crop last fall.
Lotus humistratus	2	1½	In bloom	10	
Lotus humilis	8	1½	In fruit	36	
Erodium texanum	3	3 to 4	do	6	
Lepidium lasiocarpum	1	4	do	18	
Eriophyllum lanosum	80	2 to 3	In bloom	105	
PLOT L.					
Lotus humilis	226	1	In bloom	180	Similar to K, but farther from arroyo. Besides the list, there is one plant each of *Plagiobothrys arizonicus*, *Baeria gracilis*, *Filago californica*, and *Eremocarya micrantha*. All would weigh less than 2 grains.
Linanthus bigelovii	13	2 to 3	do	6	
Linanthus aureus	2	3½	do	4	
Gilia floccosa	5	2 to 3	Under bloom	3	
Caucalis microcarpa	5	5	In bloom	6	

a Prostrate.

Tabular statement of plot measurements—Continued.

Name of plant.	Number of plants.	Height of plant.	Condition of plants.	Weight.	Condition of plot.
PLOT M.		*Inches.*		*Grains.*	
Thelypodium lasiophyllum.	7	10 to 18	In fruit	79	About one-third of plot situated under a Zizyphus bush, where the vegetation is much more abundant than in the remainder of the area, but it represents an average for this kind of situation.
Cryptanthe intermedia	5	5 to 8	In bloom	31	
Pectocarya linearis	6	1 to 3	do	20	
Caucalis microcarpa	6	2 to 3	In fruit	2	
Sphærostigma chamænerioides.	4	3 to 12	Early bloom	18	
Ellisia chrysanthemifolia.	1	6	Late bloom	6	
Sophia pinnata	12	10 to 14	do	95	
PLOT N.					
Lotus humistratus	490	1 to 3	Full fruit	1,053½	Gently sloping open foothills. *Eschscholtzia mexicana* very abundant a short distance away, but comparatively few plants within 20 rods of the plot. Besides the plants listed there are 31 seedlings of *Gærtneria tenuifolia* and 10 bunches of perennial grasses.
Plagiobothrys sp	2	1 to 2	In fruit	4	
Plagiobothrys arizonicus	9	3 to 5	Late fruit	22	
Linanthus aureus	8	1 to 3	Late bloom	2	
Pectocarya linearis	8	2 to 4	Late fruit	8	
Eremocarya micrantha	32	1 to 1½	do	5⅗	
Plantago ignota	374	1 to 3	In fruit	283	
PLOT O.					
Mentzelia albicaulis	1	6	In fruit	3	On a sandy, gravelly wash which has not been disturbed for about two years. The plants in situations like this habitually grow much larger than in other places. They are, however, much fewer in number.
Phacelia crenulata	2	4	In bloom	4	
Lupinus leptophyllus	1	4	In fruit	27	
Gilia inconspicua	6	8 to 12	do	92	
Gilia floccosa	3	3 to 4	do	27	
Eschscholtzia mexicana	1	5	Late bloom	2	
Plantago ignota	1	5	In fruit	26	
Eremocarya micrantha	2	2 to 4	do	10	
Lupinus concinnus	2	3 to 5	do	101	
Pectocarya linearis	1	3	do	8	
PLOT P.					
Plagiobothrys arizonicus	56	5 to 10	In fruit	1,905	Typical representation of the uneroded lands just above the washes and below the rocky bluffs on either side. It is between areas of this nature and the sandy washes that trees and shrubs grow in this part of the inclosure.
Lupinus concinnus	4	3 to 4	Late bloom	116	
Malacothrix fendleri	1	4	In bloom	8	
Gilia floccosa	2	3½	do	21	
Linanthus aureus	2	3	Full bloom	6	
Gilia inconspicua?	11	7 to 11	In fruit	81	
Phacelia arizonica	1	3½	Late bloom	10	
Astragalus nuttallii	1	3	In fruit	2	
Eremocarya micrantha	11	1 to 2	do	18	
PLOT Q.					
Ellisia chrysanthemifolia	4,612	3 to 7	In bloom	1,008	Typical development in the protection of bushes.
PLOT A′.					
Atriplex elegans	10	12	Mature	968	Uneroded. In other respects not different from Plot A.
PLOT B′.					
Atriplex elegans	72	4 to 6	do	1,614	Surface soil partially removed by erosion.
Portulaca retusa	106	3	In bloom	126	
Bouteloua aristidoides	2	4	Mature	1	
PLOT C′.					
Atriplex elegans	82	14	Mature	4,479	Surface soil largely removed by flood waters.

Tabular statement of plot measurements—Continued.

Name of plant.	Number of plants.	Height of plants.	Condition of plants.	Weight.	Condition of plot.
PLOT D′.		*Inches.*		*Grains.*	
Bouteloua rothrockii	82	18 to 24	Mature	1,560	In the upper end of a small stony arroyo.
Allionia incarnata	1	1 to 2	In fruit	31	
Bouteloua havardii	1	12	Mature	106	
Machaeranthera sp	22	3 to 7	Late bloom	204	
Aristida americana	2,604	4 to 9	Mature	504	
Eriocarpum gracilis	10	7	Late fruit	36	
Gærtneria tenuifolia	5	16	In fruit	136	
PLOT E′.					
Bouteloua bromoides	130	5 to 8	Mature	4,910	On the bank of a small stony arroyo.
Aristida americana	15	4	do	1	
Bouteloua havardii	26	5 to 9	do	172	
Eriocarpum gracilis	18	3 to 5	Overmature	42	
PLOT F′.					
Bouteloua aristidoides	1,148	6 to 8	Mature	2,305	On a sandy alluvial bank about 8 feet above the shifting sands.
Tribulus grandiflorus	30	4	Overmature	128	
Amaranthus palmeri	4	6	Mature	22	
PLOT G′.					
Bouteloua bromoides	158	6 to 10	Mature	1,326	On the broad upper end of a shallow wash west of Proctor.
Aristida americana	903	2 to 4	Overmature	84	
Aristida americana bromoides.	3	12 to 18	Mature	82	
Eriocarpum gracilis	6	3 to 5	Late bloom	60	
Eriogonum polycladon	15	7 to 24	Full bloom	450	
PLOT H′.					
Bouteloua bromoides	4	6 to 7	Mature	38	On a rocky western exposure. *Calliandra eriophylla* very abundant, there being 15 small plants upon the plot.
Bouteloua eriopoda	20	8 to 12	do	154	
Bouteloua havardii	16	6 to 10	do	120	
Eriocarpum gracilis	72	3	Overmature	122	
Bouteloua hirsuta	5	8 to 12	Mature	70	
PLOT I′.					
Panicum arizonicum	1	3	Overmature	1	On a sandy wash. The soil has been undisturbed for about one year.
Bouteloua aristidoides	88	1½ to 5	do	28	
Eriocarpum gracilis	2	10 to 12	do	33	
Bouteloua rothrockii	1	18	Mature	33	
Eriogonum polycladon	1	24	Full bloom	139	
PLOT J′.					
Bouteloua artistidoides	7,854	3 to 4	Mature	1,890	A distinctly six weeks' grass (*Bouteloua aristidoides*) area.
Aristida americana	168	6 to 8	do	42	
Bouteloua eriopoda	1	10 to 12	do	32	
Eriocarpum gracilis	42	6	Overmature	336	
PLOT K′.					
Machaeranthera sp	3	4	Late bloom	173	Upon a gravelly knoll where it requires an exceptionally favorable year to produce any feed.
Bahia absinthifolia	1	5	Early bloom	1,467	

The following table giving totals computed from the preceding tables is more convenient of reference and shows in connection with figure 1 the relative productivity of different portions of the field:

Totals compiled from previous tables.

Plot.	Total number of plants on 21 square feet.	Weight of plants on 21 square feet.	Average weight of plants.	Computed dry weight upon 1 acre.
		Grains.	*Grains.*	*Pounds.*
A	62	370	5.97	109
B	63	1,815	28.81	537
C	9	51	5.66	15
D	47	416	8.85	123
E	411	1,710	4.16	507
F	390	985	2.53	291
G	442	2,126	4.81	629
H	139	187	1.35	55
I	175	482	2.75	143
J	303	749	2.47	221
K	347	1,053	3.03	312
L	251	199	.79	58
M	41	251	6.12	74
N	297	1,378	4.64	408
O	20	300	15.00	88
P	42	2,455	58.45	727
Q	172	1,008	5.86	298
A′	10	968	96.80	286
B′	91	1,741	19.13	515
C′	82	4,479	54.62	1,327
D′	188	2,577	13.71	763
E′	102	5,155	50.54	1,529
F′	142	2,695	18.98	798
G′	146	1,902	13.03	562
H′	81	504	6.22	149
I′	49	234	4.78	69
J′	385	2,300	5.97	1,150
K′	4	1,640	410.00	486

The last column of this table is of special interest. It shows a wide variation in the quantity of vegetation which is produced even in areas situated near each other. It must be borne in mind that the most productive plots represent comparatively small areas. The tables also show a greater average of summer growth, the average for the spring being 270 pounds per acre and for the summer season 799 pounds, or an average for the entire year of 1,069 pounds per acre.

In interpreting these figures it must be remembered that they represent very closely the total herbaceous growth and that some of the plants listed are not eaten by stock when there is more palatable feed to be had, while others are eaten only in part. In estimating the amount of stock feed, therefore, it is necessary to make a liberal deduction from the above figures. The method of making the estimate

must also be taken into account. Every plant upon the plots was pulled up and the roots cut off at the surface of the ground. The weights given, therefore, include all of the plant which grows above ground. It is needless to say that it would be impracticable, indeed impossible, to take the vegetation off the ground as closely as this by grazing. Furthermore, the method practiced in obtaining these estimates removes all vegetation, leaving no seed for annual species and no cover for the roots of the perennials. Another very important factor to be considered is the fact that so many of the annuals which make good feed while green are of practically no value when once they are dried. As an example of this may be mentioned *Pectocarya linearis* and the majority of the other borages. Even if it were possible to utilize the entire development of vegetation except what should remain for seed, it would have to be done to a very large extent, especially in the case of the spring annuals, before they ripened. Attention is called especially to the fact that it would be impossible for cattle to secure the same amount of feed that is indicated in the above totals. The above apparent large yields must be considered in connection with what is actually secured from pastures under proper grazing methods in more productive parts of the country. Where blue-grass pastures are properly grazed, and upon closely cut lawns, there is not less than 1,500 to 2,000 pounds of material left upon the ground continually, and a timothy meadow from which 2 tons of hay per acre has been removed has not less than this number of pounds remaining in the stubble. It will be seen from these measurements, therefore, that the entire herbaceous development upon this tract is not over two-thirds of what remains upon the ground, ungrazed and uncut, in good pastures and meadows.

To carry the computations and comparisons still farther, we can say that as a general rule one-third of the hay and pasture plants are left in the stubble. From the yields obtained here for the plants which are not eaten by stock, or only eaten in part, 50 per cent should probably be deducted. Deducting therefore 50 per cent for plants not eaten, and an additional $33\frac{1}{3}$ per cent for the quantity which should be left upon the ground for the protection of the roots mainly, in the case of perennials and for reseeding in the case of annuals, we have left in round numbers an average of 350 pounds per acre as the total herbaceous production available for stock feed. From this 350 pounds per acre another large deduction must be made for plants which are of forage value for only a short time during the season and therefore are capable of only partial consumption. The borages have been mentioned in this connection, and a score of others might be enumerated. Even Indian wheat is of little value after it has dried up, for the seed falls to the ground very soon after maturity, and the remainder of the plant is not eaten in the dry condition. In the same category belong

the annual grasses *Bouteloua aristidoides* and *Aristida americana*, which without doubt produce as many pounds of growth upon the inclosure as all other grasses combined. It is very doubtful if these are eaten except under enforced conditions after the seed begins to ripen. Their period of usefulness as stock feed is therefore very short. Fifty per cent more should be deducted from the total available for stock feed for plants of this kind which are of little or no value when dry and therefore are not capable of complete consumption. The two species of lotus enumerated in the record of plot measurements and Pectocarya are from their habits of growth not grazed to any extent, by cattle especially, until they begin to fruit, on account of their lying flat on the ground until this time. Their period of usefulness is therefore very short. When this deduction is made, and it is believed that all of these deductions are conservative, we have left 176 pounds of dry feed per acre to be utilized under necessarily wasteful pasture practices, where green feed is present for about five months, and the season of grass production in July to September is often closely followed by a few light showers of rain, which greatly decrease the value of the cured forage. This remainder of 176 pounds is increased somewhat by the browse plants, which have not entered into our calculation.

If we consider 18 pounds per day of well-cured hay sufficient for the maintenance of a mature idle animal without adding anything to its weight, it will require 37 acres to support such an animal one year. This calculation considers the native feed equivalent to well-cured hay and allows nothing for increase in weight. Neither does it allow anything for labor performed by the animal in gathering its food and walking a distance of 5 to 10 miles for water. When additional allowances are made for these factors, the number of acres required to pasture one animal is very materially increased and approaches very closely the 50-acre estimate given upon a previous page.

CARRYING CAPACITY.

Before any rational adjustment for the proper control of public grazing lands to meet the evident pressing demands for a change in this direction can be made, much should be definitely known regarding the amount of stock that these lands will carry profitably year after year. This must form the basis of all equitable allotments. To secure such information is a most difficult task in a region where the seasons, the altitude, the slope, and the rainfall are so variable. It can be determined very easily in the Great Plains region, where conditions are uniform and reasonably constant, and indeed it is very definitely known there; but here the case is very different. There is in the Territory comparatively little native pasture land under fence, and that which is fenced is usually the better land, representing a

much higher carrying capacity than the average. Even in cases where the land is fenced the areas are irregular, and therefore of uncertain acreage, with no record of the amount of grazing secured from them. The estimates below are given, therefore, reservedly, but with a feeling that they are approximately accurate for the specific areas mentioned.

Mr. W. B. McCleary has 200 acres fenced at the base of Mount Wrightson, at an altitude of approximately 4,000 feet. The conditions are approximately the same as those in the southernmost part of the area recently inclosed by the Department, except that a portion of Mr. McCleary's holding is occupied by a large wash heavily covered with brush and trees. When first fenced, it was necessary to feed some hay to the four head of stock which are carried on the land, but at the present time the area furnishes sufficient feed for this number. Mesquite beans and browse furnish no small part of the feed, and in general the area represents about an average carrying capacity for the foothill-mountain areas. It furnishes rather more browse and mesquite beans but less grass than some of the neighboring localities. In the estimate of this pasture, if the data which it furnishes be correct, the carrying capacity for the best pasture lands in the foothill-mountain areas of this region is about 1 head to 50 acres. This is probably not far from the proportion which should govern grazing upon these lands. It should be stated that this estimate is based upon the better lands, which are proportionally smaller in area than desert mesas and unproductive lands at lower altitudes.

Much effort was made to get an estimate of the carrying capacity of the land in the northern part of the Territory, where the task is even more difficult than it is farther south. The figures given for this region are purely estimates based upon the judgment of ranchers who operate in the region. A great many ranchers were consulted and their opinions secured, but the two or three quoted below seem to be based upon the most definite data.

Some information received from Mr. George L. Brooks, manager for a cattle company, shows the extent to which the country has been overgrazed in past years. The lands of this company are located from Aztec west to Angel and south to the limit of the old Atlantic and Pacific grant. This strip of country contains a little more than 1,500,000 acres. Mr. Brooks, who necessarily made a very careful study of the matter, estimates that there were upon this area for a number of years an equivalent of upward of 44,000 bovine animals, or about 1 steer to 34 acres. The loss of cattle through starvation was tremendous for several winters, and the country became so badly damaged as to compel the company to go out of the cattle business. Their losses from theft, no doubt, were considerable, but the land could not maintain stock at the above ratio. At the present time

there is very little grazing on this territory except by sheep during the winter season.

A rancher near Ashfork, who pastures 1,000 head of cattle, this number of stock now having the entire run of land composing nearly eight townships, thinks that they could be carried with perfect safety on four townships. This gives 92 acres to 1 head, which seems to be a liberal allowance, and the lands would probably carry stock at the ratio of 1 bovine animal to 100 acres indefinitely.

The higher lands in the San Francisco Mountains of course produce much more abundantly than the bench lands at lower altitudes or in the valleys of the Colorado and the Little Colorado. Practically no grazing is done here, however, except in the summer season, and an estimate of the carrying capacity must, therefore, be made on an entirely different basis. The better lands here would probably support 1 sheep to 5 acres during the grazing season from May to November. This, according to the usual method of calculation, would mean 1 steer to 30 acres for the same season.

Twice during the past season the goat ranch of Mr. Joe Mayer, at Mayer, Yavapai County, Ariz. (Pl. VII, fig. 1), was visited. Mr. Mayer has run goats for a number of years on the same territory, and his estimate of the carrying capacity of this ranch is probably as accurate as can be obtained at the present time. During the course of a conversation in July Mr. Mayer stated that, as nearly as he could judge, he is using between 3 and 4 acres of land for each animal. The estimate obtained from one of the herders of the area grazed during the season gives a somewhat higher allowance for each animal. It should be borne in mind that this estimate can not be reduced to terms of bovine animals very safely, because goats thrive upon vegetation which is not eaten by cattle or, if eaten, upon which they can subsist but a short time. The ranch is located in the mountains where scrub live oak abounds, upon which the animals live exclusively for a large part of the year.

WATER FOR STOCK.

One of the most perplexing problems of the ranchmen throughout the Territory is that of the proper distribution of water for stock purposes, and every contrivance known is employed to secure this most important adjunct of the stock business. Besides the natural supplies of springs and streams, wells and surface tanks are commonly used. Many regions are so remote from available water supplies that they are not grazed except during the cooler or more moist portions of the year, when stock can endure long periods without water, or when there is temporary water in the rivers, arroyos, and natural tanks. Water is so difficult to secure in many places that the lands can not be grazed even during this season. This condition is

especially true of the higher mesas remote from both mountain ranges and river valleys where neither short streams nor small springs of the mountain valleys nor the underground water supply are available.

Central Pima County, embracing Avra, Altar, Santa Rosa, and Babuquivari valleys, is especially noted for its deep wells furnished with steam pumps. The ranches in this region are very sparse, and consequently these always furnish water for the pasturing of very large areas. Some of these wells are upward of 800 feet in depth. The fuel used for pumping is almost entirely mesquite from the immediate vicinity. The supply of water at these depths appears to be inexhaustible.

The ranches situated higher in the foothills and mountains depend upon springs and shallow wells operated by windmills. The supply of water from these shallow wells, however, often varies greatly from season to season, the difference sometimes being as high as 30 feet between the level of the water in moist and dry seasons. Upon the river bottoms the natural flow of the rivers is supplemented by wells during the dry season. These are operated by steam, horse, or wind power. On account of the absence of streams and the great difficulty of obtaining well water, a large part of the northern portion of the Territory is obliged to resort to surface tanks built of earth as the only available means of supplying water to stock. Upon the higher areas in the San Francisco and contiguous mountain ranges water is abundant enough in the average season for all purposes, but upon the lower plateaus the case is very different. Here the prospective rancher is often deterred from entering the stock business on account of the great expense involved in securing water. Under a system of more stable tenure the expense might not be prohibitive, for it is estimated that tanks which hold water for one year can be built for about $500. The clay soils so common here are admirably adapted to the construction of tanks of this kind, for they hold water almost perfectly when once thoroughly tramped and compacted. In some places natural tanks are found which need only to be filled by having water conducted into them by ditches or embankments.

Another consideration which renders water relatively expensive is the low carrying capacity of the land, which decreases the number of stock which can be profitably watered in one place, making the returns for outlays much smaller than they would be under more productive conditions of soil and rainfall. Every rancher who develops water here in any form of course owns the land upon which the water is situated, but even this ownership counts for but little under the present uncertain tenure of the surrounding areas. In short, water development being expensive and the carrying capacity of the land low at best, a large acreage is necessary to furnish a livelihood.

So far as cattle especially are concerned, Arizona is essentially a

breeding ground for animals which are fattened elsewhere. It would seem, however, that this would not be the case long, for the present irrigation projects, when developed, will greatly increase the feeding facilities of the Salt and other river valleys, so that many more cattle can be matured. At present, and for a long time past, practically no cattle leave the Territory in condition for the markets. This, however, is true at the present time of nearly all the native pasture regions in the United States.

Throughout the Territory, excepting in the vicinity of the irrigated regions of the Salt and Gila valleys, no hay or other feed is furnished stock. They live upon the native vegetation, consisting of grass, weeds, or browse, depending upon the locality or the season of the year. The main concern of the rancher is with branding, preventing theft, and furnishing water. It will not be long, however, under the present management of the live stock sanitary board, before thieving, which has obtained so commonly and has been the means of ruining a great many stockmen, will be a thing of the past. The scarcity of water, coupled with the small carrying capacity of the ranges, compels cattle to travel long distances. These distances would be considered prohibitive upon the native pasture lands of the Great Plains; but the development of water at intervals of 2 or 3 miles, such as is advocated and practiced there, could not be thought of here on account of the great expense and proportionally small returns.

The readiness with which stock of all kinds adapt themselves to the enforced conditions of shortage of water is remarkable. It is not, however, without great loss at certain seasons, and it is those who make the best provision for watering who are the most successful in the business. The influence of a good supply of wholesome water is very noticeable during the dry season from April to July. Abundant opportunity was had during the past year for observation on this point, inasmuch as the greater part of the dry season was spent in the southern portion of the Territory. It was evident that cattle having plenty of water and living upon mesquite and cat-claw browse were able to live through this period in better condition than those upon better pastures but with inconvenient water supply.

It is not to be supposed that cattle go to water even once a day when feeding grounds are so remote. Indeed, the habits of cattle have been so often observed by so many people that it is well known that they very often, even during the hottest weather of summer, go to water regularly only every second or sometimes every third day, if the distance is very great between water and feed. Mr. Truax, foreman of a cattle company of Apache County, relates some of his experiences in this matter. A few days before arrival at his ranch, on the 9th of August, he followed a bunch of cattle which watered at the corral at daylight in the morning. About the middle of the afternoon

they were 8 miles from the ranch. He further states that his cattle often go 10 or 15 miles away from water. It hardly seems probable, however, that cattle can accustom themselves to living over twenty-four hours without suffering in the extreme heat of summer, although they thrive for a much longer period, as shown by the following signed statement, which was recently furnished at my request:

HELVETIA, ARIZ., *July 13, 1903.*

In the month of July, 1900, in building a fence for a pasture, we inclosed a 3-year-old steer. The fence was completed on the 5th of July, and the steer to our knowledge was in our pasture thirteen days without water. We will state further that there was no grass in the pasture, but there was plenty of mesquite and cat-claw browse.

W. B. MCCLEARY.
J. MARTIN.

Mr. Truax relates a still more remarkable instance than this one, in which he states that his men accidentally inclosed a cow and calf in a dry pasture in the month of July, where they remained for a period of fifteen days before being discovered. The calf at the end of the period was in apparently good condition, but the cow could not have lived much longer. These extreme cases are quoted to show that it is not at all impossible for stock to live regularly even under this subtropical heat with but two or three waterings per week, although the practice can not be upheld where there is any possibility of supplying water at shorter intervals and more convenient distances.

In many countries where sheep are extensively raised they are almost never watered, but in dry regions water must be supplied, although at rather less frequent intervals than is the case with cattle. Upon the high plateau of the Ash Fork and Seligman regions herders informed the writer during the past season that they do not water more often than once every eighty hours in the hottest weather. They remain three nights away from water with both sheep and pack burros. In this way they are able to graze an area around the water supply with a radius of about 6 miles, or about 72,000 acres. Even with this remarkable utility of water there are large areas where grazing can not be done except during the rainy season or in winter when there is snow upon the higher elevations. During a large part of the winter, when grazing is done upon alfilerilla and Indian wheat, sheep live without water for months. Little or no water is needed even in summer when feed is green.

Goats need water more often than sheep, and it is usually claimed that they can not get along without water once every twenty-four hours. They are much better travelers than sheep, however, and on this account fully as large an area can be grazed from one watering place as with sheep. Mr. J. F. Burns reports that his 500 Angoras traveled 14 miles each day for about two weeks one year with no appar-

ent inconvenience. This means that nearly 150,000 acres could be grazed from one watering place. This amount of travel, however, is excessive, and without doubt could not be profitably continued. Mr. Mayer's herders report that their flocks do not travel over 5 miles per day, but they think that there would be no evil effect from driving them farther than this. Considering the necessity of watering more often, it is probable that no greater area can be grazed with goats than with sheep.

Horses have no difficulty in traveling 20 miles to water, it is claimed. Some portions of Arizona are overrun with cayuses of little value, a large number of which are unbranded and badly inbred. They are claimed, of course, and, being upon public range, can not be gotten rid of. Horses and burros have a decided advantage over cattle, not only from the fact that they are better travelers, but because they are able to dig for water in the sands of the arroyos. It is a novel sight to the uninitiated to see a horse or burro up to its knees in the loose sand pawing for water. During the summer rains the water level is high in the arroyo sand for some time after a shower, although there may be no running or standing water for miles around. Horses and burros very commonly supply themselves with water during the summer season in this way, and are, therefore, able to graze upon lands that cattle or even sheep can not reach. Plate III, figure 1, shows horses digging for water in a small arroyo at the western base of Pyramid Hill, within the present inclosed area on the Santa Rita Forest Reserve.

By far the greater number of sheep and goats are summered in the great highland region of the San Francisco, Mogollon, and White mountains, and wintered upon the deserts of the Salt, Colorado, and Little Colorado river valleys. This statement should be modified by the assertion that the Navajo and Moqui sheep are not included. The rainfall is so variable, however, that there is no regularity in the migrations. The exact locality where a man winters depends entirely upon the distribution of the rainfall of the late autumn of that particular season.

THE SEASONS.

There are in southern Arizona two distinct seasons of feed production; in other words, two seasons of plant growth. They are totally different in the class of plants which they produce; indeed, one can almost recognize three seasons of growth if he takes into consideration those plants which grow well during the hot weather of May and June upon the moisture which they have stored up during the winter.

The first season draws to a close with the advent of the April drought, which continues to the first of July. The second begins with the summer rains of July and terminates early in October. The

spring season is largely dependent upon fall rains to start the vegetation, which grows very slowly during the winter and matures in the spring. Of course not all of the spring plants germinate in the autumn, but there is a large class of very conspicuous and important things which do germinate as early as the latter part of September, make a good growth before the cold weather sets in, grow very slowly during the cold weather, and mature in the spring. This cycle is entirely dependent, however, upon the distribution of moisture. If the months of September and October are dry no germination takes place until moisture comes in late winter. If this continues long enough in the spring a crop matures; but if not, as is usually the case, these plants dry up and there is no more feed produced until the summer rains come again.

From April to June, although it is very dry, there is a considerable development of plants which have some special provision for retaining or securing a supply of moisture. The development of these is usually not perceptible until the season of drought. Indeed, it is after the dry hot season begins that they begin their growth. Attention should be called here to the fact that it is only those plants which have means of supplying themselves with water that grow during the dry season. Those plants protected by varnish, or by having power to discard their leaves, etc., use these contrivances to enable them to live, not grow, during the dry season. The case is very different with the majority of the cacti, which store vast quantities of water in their tissues. They grow without apparent hindrance through the dry season of early summer. They are of value as food for stock, and would be closely grazed were it not for their offensive spines. The native gourds, devil's claw, the native night-blooming cereus (*Cereus greggii*), one of the ground plums (*Physalis* sp.), birthwort (*Aristolochia brevipes*), and numerous others that might be enumerated, have storage reservoirs in the form of enlarged roots. These plants, however, are of little forage value. The mesquite, on the contrary, is able to thrive through a long period of drought with no appreciable storage of water, but it is a very deep-rooted plant, and growing to best advantage along river courses and arroyos it gets water from the deeper strata there much longer than the shallow-rooted plants, and is therefore able to grow well into the summer dry season, if not fully through it into the moist summer season without being checked. During the past year this tree was in full bloom about the middle of May upon the northwestern part of the large inclosure, and it was almost completely defoliated by a lepidopterous larva by the last of the month. On the 26th of June it was again in full bloom and had nearly recovered from the effects of the defoliation. During the period from April to June there had been 2.9 inches of rain at McCleary's camp, and but 0.42 inch at Tucson. The rainfall in the mountains at

McCleary's did not reach the area in question, and as nearly as can be judged the rainfall here at this period was little if any greater than at Tucson. The effect upon the deep sands of the washes, however, was considerable, no doubt, and the deep roots of the shrubs were able to profit by it.

The winter season is characterized by an abundant (relative) growth of short-lived annuals. Some of these, as before stated, start their growth in October, or even September, at the close of the summer rainy season. Among these may be mentioned *Pectocarya linearis*, alfilerilla, Indian wheat, and a large number of boraginaceous plants which furnish a great deal of feed. Between this time and the 1st of February (it is not definitely known at what time, and, indeed, the time varies owing to the variation in precipitation) there appear a host of other short-lived plants, a large number of which are of some forage value. These are ephemeral, especially in their effect upon the landscape and in their forage utility, although they are really in the vegetative state a considerable period. The time of maturity of these winter and spring annuals in the same season is very variable, there being from two to three weeks' difference between the mesas about Tucson and the northern slope of the Santa Rita Mountains or the eastern slope of the Babuquivaris. This vernal development is mostly confined to altitudes below 4,000 feet in southern Arizona, the regions above this having really but one prominent vegetative season. The cause of this is mainly the lower temperatures of the higher altitudes, there being too low a temperature for the growth of the annuals at a time when the winter and early spring moisture is present. By the time the temperature is high enough for plant growth the moist conditions have disappeared, and there is practically no growth of vegetation, except during the summer rainy season. A very large part of the best pasture lands of this section, therefore, has but one season of plant growth.

The summer season is characterized by the production of grasses of a great variety of species. Upon the lowlands the greatest development is upon the flooded areas, which were much more abundant formerly than they are now, owing to the excessive erosion which has taken place during recent years. Upon the mesas there is but little development of perennial grasses as a usual thing, unless these mesas be high. In favorable places and in favorable seasons there are a few perennials which make considerable feed. Upon the mesa swales galleta (*Hilaria mutica*) is an important grass, while upon the less favorable situations species of grama grass sometimes make a thin growth. It is on the foothills and mountains that the grasses make their best and most pronounced growth. Here the rainfall is more abundant during the summer season than upon the lower areas, although there may not be such a difference in the winter rainy season, and the growth of grasses is proportionately

larger. Nearly all grasses are in bunches and often grow 2 or 3 feet high, but always scattering. It is only in favorable depressions, where the land gets an increased quantity of moisture that there is a sufficient amount of development to produce a complete ground cover. The summer season of growth depends not only on the amount of rainfall, but upon its distribution during the period from July to September.

The following table of rainfall, prepared from Weather Bureau observations at Tuscon during the years 1902 and 1903, illustrates very nicely the difference between what are considered years of plenty and years of famine in the range business in this region:

Table showing difference in amount and distribution of precipitation in a good and in a poor season.

[Precipitation expressed in inches.]

Month.	Year.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
January	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
February	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1903	.....	0.20	0.11	.....	0.14	0.31	.....	.....	0.02	.....	.....	.....	.....	0.08	0.25	.....
March	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.01	.....	.....	.....	.....	.....	.....
	1903	.....	.03	.01	0.01	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
May	1902	.....	.....	.....	.....	.....	.....	T.	.....	.....	.....	.....	.....	.....	T.	.....	.....
	1903	.....	.....	T.	.07	.....	.....	.....	T.	.....	.....	.....	.....	.....	T.	.13	T.
June	1902	.....	.....	.....	.....	.....	.....	.....	.....	T.	.....	.....	.....	.....	.....	.....	.....
	1903	.....	.....	.....	.....	.....	.....	.....	.....	T.	T.	0.22	.....	.....	.....	.....	.....
July	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.....	.....	.....	.10	.04	.....
	1903	.....	.....	.....	.....	.....	.16	.....	0.23	.....	T.	T.	T.	0.01	.08	.11	0.67
August	1902	.....	T.	.....	.46	.....	T.	0.07	.05	T.	.....	.53	.....	.....	.....	.....	.....
	1903	.....	.....	T.	.04	T.	.11	.97	.03	.20	.....	.07	.....	.....	.....	.....	.....
September	1902	.....	.....	.....	T.	.....	.06	T.	.....	.....	.17	.....	.....	.....	T.	.16	.....
	1903	.....	.....	.....	.....	.05	.14	.....	.01	.....	.....	.....	.....	.....	.....	.....	.....
October	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
November	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.21	.29	.....	.....	.....	.....	.....
	1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
December	1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.50	.91	.42	T.	.....
	1903	.....	.....	.....	.....	.....	.10	.14	.03	.....	.....	.01	.....	.....	.....	.....	.....

Table showing difference in amount and distribution of precipitation in a good and in a poor season—Continued.

Month.	Year.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	Total.
January	1902									0.10	0.09	T.		0.20	0.14		0.53
	1903																
February	1902										T.						
	1903										T.						1.11
March	1902			0.02					0.41			T.					.44
	1903								.03	1.42	.13	T.					1.63
April	1902					T.											T.
	1903																
May	1902																T
	1903																.20
June	1902					T.							0.09	.03	.07		.19
	1903																.22
July	1902					0.05	0.21	0.01			T.						.42
	1903				0.04	.01		.02		.15	.04						1.52
August	1902	0.05			T.		T.	.15				T.		T.			1.31
	1903									.01	.99			.25			2.67
September	1902		0.09	.01	.09												.58
	1903					T.	T.			T.		0.96	.01				1.17
October	1902													1.64			1.64
	1903																
November	1902				T.	.46	.02	T.						.40			1.34
	1903																
December	1902															0.32	2.15
	1903																.28

Several important points should be noted in connection with this table of rainfall. Although arranged by calendar years, it should not be studied according to this division, although this might be done in other regions. The total rainfall of these two years was practically the same, but the good rains of October and November, 1902, with the rainfall of March and April, 1903, were the means of producing good feed during the early part of the latter year, while the rainfall of the latter half of the year 1902, although above normal, produced very poor summer feed on account of its improper distribution. It fell mainly between the 29th of October and the 14th of December, too late for the proper development of the grasses, which thrive here only under intense heat and considerable moisture. The precipitation during July, August, and September, 1903, was good and well distributed, but the fall during the last three months of the year was too light to augur very auspiciously for the winter of 1904, although the good rainfall of September was sufficient to start the annuals beautifully. It should be stated that these conditions do not bear much generalization, they apply locally where the observations on precipitation were made very well, but they may not apply at all in localities somewhat removed. For instance, the feed upon the inclosure in the Santa Rita Mountains was much better in the summer of 1902 than in the same

season of 1903. This, of course, was due to a difference in conditions, which is shown by the following table, in which it will be seen that the rainfall of July was just twice as great at McCleary's camp as at Tucson, slightly less in August, but still a good amount, and decidedly more in September:

Comparison of monthly totals of precipitation at Tucson and McCleary's camp.[a]

Month.	Tucson.			McCleary's camp.		
	1902.	1903.	Average.	1902.	1903.	Average.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	0.53	0.00	0.24	0.67	0.10	0.38
February	.00	1.11	.55	.00	1.48	.74
March	.44	1.63	1.02	.85	1.59	1.22
April	.00	.00	.00	.11	.00	.05
May	.00	.20	.10	.15	.99	.57
June	.19	.22	.20	.50	1.10	.80
July	.42	1.52	.99	.90	3.04	1.97
August	1.31	2.67	1.96	3.07	2.45	2.76
September	.58	1.17	.70	3.45	1.99	2.72
October	1.64	.00	.82	.15	.00	.07
November	1.34	.00	.71	2.72	.00	1.36
December	2.15	.28	.71	1.05	.12	.58
Yearly total	8.60	8.88	8.74	13.62	12.86	13.24

[a] Observations at Tucson from U. S. Weather Bureau records, and at McCleary's camp by Mr. W. B. McCleary.

The unproductive condition of the present public lands is often attributed to drought during recent years. It is a very common thing to hear ranchers speak of the prolonged droughts during the last few years, and attribute to these the shortage in feed and the consequent decrease in the cattle industry. The majority of ranchers, however, agree that the carrying capacity of the lands is necessarily small and always has been, but that they were led to believe in the early history of the cattle business and at a time when the old vegetation upon the ground was an accumulation of long standing that the carrying capacity was much greater than it really is. This old vegetation having been eaten off and tramped out by more stock than ever should have been placed upon the land, coupled with the evil effects of erosion, described elsewhere, account for the present conditions.

The following table shows that the precipitation during the past five years has been somewhat less than during the previous four years, and that the average for the past five years has been but 0.95 inch less than the average for the past fourteen years. This table, prepared from Weather Bureau observations at Tucson, shows the total of precipitation by months and years for the past fourteen years.

Monthly totals of precipitation at Tucson, Ariz., for fourteen years.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1890	0.53	0.52	0.62	0.59	0.75	0.83	0.88	0.83	0.77	0.86	0.60	0.52	8.30
1891	.12	2.08	.17	.00	.18	.22	.70	2.26	.65	.00	.00	.23	6.61
1892	1.52	2.63	.98	.18	.17	.10	1.00	2.14	.37	.27	T.	.25	9.61
1893	.27	.82	1.16	T.	.75	.00	2.78	5.40	1.02	.00	.43	.49	13.12
1894	.11	1.04	1.17	T.	.05	T.	1.60	1.01	.12	.31	.00	1.88	7.29
1895	.56	T.	.00	T.	.09	.02	.11	4.48	.75	.68	4.30	.08	11.07
1896	.53	.08	.27	.12	T.	.19	3.45	1.25	1.13	3.31	.30	.76	11.39
1897	1.79	.08	.13	.00	.00	.00	1.98	3.42	2.71	.54	.00	.11	10.96
1898	1.10	T.	.63	1.05	.00	.20	3.22	3.94	.10	.00	.85	1.63	12.72
1899	.78	.39	.37	.62	T.	1.27	1.87	1.82	.03	.67	.56	T.	8.38
1900	.16	.49	.54	1.12	T.	.17	.65	.95	.85	.41	2.45	T.	7.79
1901	1.15	1.38	.64	.04	.41	.00	2.57	1.99	.28	1.18	.08	.00	9.72
1902	.53	T.	.44	T.	T.	.19	.42	1.31	.58	1.64	1.34	2.15	8.60
1903	.00	1.11	1.63	.00	.20	.22	1.52	2.67	1.17	.00	.08	.28	8.80
Mean	9.15	10.62	8.75	3.72	2.60	3.41	22.75	2.39	.75	.71	.78	.60	9.60

EROSION.

The entire absence of a sod, a soil very slowly permeable when once thoroughly dried, steep grades, violent windstorms, and torrential rainfalls of short duration are the elements which are calculated to produce erosion in its most violent forms. Coupled with these natural conditions, excessive stocking, with scarcity of water, compelling cattle to travel long distances to feeding grounds over surfaces easily pulverized, enhances very much the erosive action of the natural elements. There always were deep gorges, cuts, arroyos, and washes in the foothills, mesas, and other sections having steep grades; but the cutting of the river channels into deep gorges which effectually drain the bottoms instead of allowing the water to spread over the broad, fertile lands is a distinctly modern condition, directly traceable to the effect of the white man's operations. (Pl. V, fig. 2.)

One of the most serious questions which confronts the rancher to-day is how to prevent this gullying. While the loss of the land itself is not, the loss of the water is a serious matter. The flood waters which once spread over the river bottoms with practically no channel are now sunken from a few feet to 20 feet below the surface, and are carried off, together with all the rich sediment which they contain.

Several ranchers whom the writer has met have been obliged, within recent years, to devise means to mitigate this evil. It is often impossible or impracticable to do anything in those cases where the cutting has progressed very far, but on the other hand it is not at all impossible nor impracticable to prevent further depredation by attacking the matter at the most advantageous point. The difficulty with work of this kind is its expense compared with the productivity of the land when no water is present for irrigation.

Two general processes are in vogue for counteracting the effect of the sinking of the water channels. The first consists in planting some soil-binding grass in such situations for the purpose of preventing further difficulty. This is usually a remedial measure which does not get at the root of the matter and is capable of but limited application after the destruction is well under way. It can be applied in this region in situations which receive flood waters from higher localities. The soils where it is attempted must already be reasonably stable in order to allow the grass to get a foothold. Mr. Harry L. Heffner, manager of the Empire Cattle Company, has experimented a great deal in this matter. The plan which he has adopted has been to establish plantations of Johnson grass upon the lands near the ends of the deep, narrow gorges and washes which approach the Pantano Wash, between the Santa Rita and Whetstone mountains. In these situations considerable areas of comparatively level lands are flooded one to three times during the year. Were three irrigations certain each year, the establishment of Johnson grass on such areas would be a comparatively easy matter. Indeed, two thorough floodings, together with the light showers that normally occur, would insure the establishment of this grass. It has been found that the most successful method of establishing a wash-resistant covering of this grass in such situations is by planting cuttings. Sections of the underground stems, from 8 to 12 inches in length, are inserted in the ground in rows across the wash, about 3 feet apart. In planting, a spade or bar is used to prepare the opening in the soil, and simply the pressure of the foot completes the operation when the cutting has been inserted. This operation is not so slow and tedious as would seem. The cuttings are easily dug or plowed up from fields which are in reasonably good tilth, and the planting is accomplished very expeditiously. Bermuda grass has also been tried in the more moist situations, but with very indifferent success thus far. This grass requires more moisture than it is possible to secure for it here, except where irrigation is practiced.

The second method in vogue to check and repair the damage done by flood waters is by the erection of embankments across the cuts, the object in all cases being to turn the water from its course on to higher lands and compel it to spread out over them instead of following the regular channel. Brush, stone, and earth are used in the formation of these embankments, which must be strong enough to withstand a great pressure until the course of the waters is once turned. When once the flow has been checked the filling up and leveling off of the gullies for some distance above the dams is quickly accomplished by the waters, which contain large volumes of sediment. The filling up process below the dam is a slow one, but the turning of the water from its course prevents further erosive action. Several small works of this nature have been observed in the valleys of the Little Colorado

and White rivers and some are under contemplation by Messrs. Vail & Wakefield in the Altar Valley near the Mexican border.

THE PRAIRIE DOG.

This little animal, which has caused such devastation throughout the plains region since its enemies have been killed by the rancher and his herdsmen, is without doubt migrating into new territory. The destruction wrought by it is more pronounced east and north of the divide of the San Francisco and White mountains than anywhere else in Arizona. Large areas have been completely overrun in the vicinity of Flagstaff. In August a trip was taken through a very badly infested area between Adamana and the White Mountains. Pl. X, fig. 2, shows an infested area on the northern slope of the White Mountains, which represents in some respects the greatest injury that has been observed in any region in the Territory. It is seldom that one can secure a photographic representation of the work of the prairie dog, but here the lime pebbles—or rather the lime-covered malpais rocks and pebbles—thrown out of the burrows furnish a sufficient contrast to the black malpais rocks and bare ground to give a fairly good representation of the extent of the operations carried on by these animals. There were no perennial grasses in the infested area, and but little vegetation of any kind. No area which has been visited within the Territory is so badly overrun by these animals as that in the vicinity of the old Twenty-four Ranch and southward to the base of these mountains.

RANGE FEED.

There is without doubt no part of the country where the character of the native feed is so variable as it is in the Southwest; and this in spite of the fact that the aggregate yield per acre is very low, and that two crops are produced each year upon a large part of the range country. We have a carrying capacity here varying from one animal to 40 or 50 acres to one animal to 100 acres, as compared with one to 15 acres in portions of the Great Plains. At the same time, the grasses, which are practically the only forage plants in the latter region, are much less numerous there than in the Southwest—much less numerous in point of species. Some of the most important groups of forage plants are discussed below.

THE GRASSES.

While it may be stated in general that of the forage production of the Territory as a whole the grasses form the most important part, yet the grass production is confined to the summer season of rain, and consequently there is a large part of the year during which all stock is obliged to subsist on other things. The grasses furnish good feed from July to the 1st of January, but after that date, if the normal

winter precipitation occurs, what is left of them is quite well bleached out. The value of grass for winter feeding always depends upon its being dry cured. When the winter rains come, therefore, stock begin to shun the old grass in proportion as the succulent annual stuff develops. During this cold winter and spring moist season there are, however, a few grasses which are of some importance in the forage ration upon the range. The most important of these are *Bromus carinatus*, *Poa longipedunculata*, *P. fendleriana*, *P. bigelovii*, and *Festuca octoflora*. Occasionally, however, the winter rains are prolonged into the warm spring season sufficiently to allow the perennial grasses, of which the gramas upon the open foothills are the most important, to get a start. In such a season there is some good feed produced by these in the spring, but this condition is an exceptional one, and we may say that as a general rule the perennial grasses which furnish the feed of midsummer to winter season do not grow at all in the spring. There is abundant evidence, however, that they would furnish two crops if the moisture and temperature conditions were favorable.

The most important of the grasses belong to the group known popularly as gramas (*Bouteloua* spp.), some of which are perennial and some annual. The perennials grow in the higher altitudes, and are mainly *Bouteloua oligostachya*, *B. curtipendula*, *B. bromoides*, *B. rothrockii*, *B. hirsuta*, *B. eriopoda*, and *B. havardii*, with considerable areas of *B. trifida* upon some stony, bare, high foothills. These furnish the best and most important range feed. *Bouteloua rothrockii* extends to lower altitudes than the others, and at times is strictly a mesa plant, furnishing upon favorable places and in favorable seasons a thin stand of large bunches. It is in the open foothills, however, that this species reaches its best development. Here, together with other species of lesser importance, it often makes sufficient growth for hay. The open foothills of the Whetstone, Huachuca, Santa Rita, and Babuquivari mountains, the Sulphur Spring Valley, and the high mesas between the Santa Catalina and Willow Spring mountains furnish extensive areas of this grass in favorable seasons. It is interesting to compare this distribution with similar situations in the Mesilla Valley of New Mexico, where Professor Wooton states that *Bouteloua eriopoda*, which is never an exclusive crop in southern Arizona, is often cut for hay. All of these species occur in the southern part of Arizona, but it is the blue grama (*Bouteloua oligostachya*) that is of the greatest importance in the northern part. Here it is by far the most important grass upon the high plateau surrounding the San Francisco and contiguous divides. Many of the juniper ridges so characteristic here have practically no other grass, and even this makes only a thin, short growth very different from its habit in the southern part of the Territory, where it assumes a more erect and robust character. The

northeastern part of Arizona, especially from Navajo to Chin Lee, and southward to the Long H Ranch and St. Johns does not differ materially in the higher elevations from the lower juniper areas of the plateau region. The three annual species of grama (*Bouteloua aristidoides*, *B. polystachya*, and *B. prostrata*) furnish feed of a poorer quality and shorter duration than the perennial ones. The first two species are found most abundantly from the lower areas to the higher foothills in the southern part of the Territory, *Bouteloua polystachya* furnishing much the better feed of the two, but the quantity is smaller. The third or prostrate grama is an important forage plant all through the pine region in the general highland of the White, Mogollon, and San Francisco mountains. At times it also reaches favorable situations along the Little Colorado.

The main grass in the lower areas in the valley of the Little Colorado is *Sporobolus airoides*. This valley has much in common, so far as its vegetation is concerned, with the valley of the Rio Grande farther east. *Sporobolus airoides* and salt grass (*Distichlis spicata*) furnish the greatest amount of feed here, but they never yield so abundantly as they do in the Rio Grande Valley. The former is known here as saccaton, but is very different from *Sporobolus wrightii*, which makes such a magnificent growth on some of the river bottoms in the southern part of the Territory.

Galleta (*Hilaria mutica*) is an important grass throughout Arizona, although not by any means so palatable as the gramas. It nearly always occupies swales or depressions in the mesas, and for its best development gets one or more irrigations by flood water during the year. In the past season there were small areas upon the mesas south and east of Tucson that would cut one-fourth of a ton of hay to the acre of this grass. In the northern portion of the Territory, especially near Ashfork, upon the Navajo Reservation, and along the main line of the Santa Fe from the plateau region east, except in the lower areas along the Little Colorado, this must be considered one of the most important grasses. It is often grazed to the ground continuously. Curly mesquite (*Hilaria cenchroides*), a closely related species, is of great importance upon the high, open foothills, and *Hilaria rigida* is characteristic on some of the deserts along the Gila and Salt rivers.

The great highland region of the San Francisco and White mountains furnish as good summer feed as any in the Territory, and where properly pastured the parks and open places are quite productive. Here a fescue (*Festuca arizonica*) is probably the most abundant grass, although sheep men sometimes claim that it is inferior in quality to *Sporobolus interruptus*, which also grows to the exclusion of all other vegetation over quite extensive areas upon thinly wooded plateaus. Indeed, *Festuca arizonica* and *Muhlenbergia gracilis*, which occupy large areas, are not considered such good sheep feed as *Spo-*

robolus interruptus. However, they are all grazed, and thousands of sheep live on practically nothing else for a large part of the summer. Sheep fescue (*Festuca ovina* var.) is common in portions of the mountains, but it is not so abundant nor so valuable as the other species. Strange as it may seem, the bluestem of the great plains region (*Agropyron occidentale*) produces a very important part of the range feed here. In open depressions there are often pure stands of it, which, during the past season, would cut as high as one-half ton to the acre. *Aristida purpurea* is another grass which, though not considered the best of feed, is very abundant in places, and furnishes fairly good grazing when young. Among other grasses of importance here should be mentioned *Kœleria cristata*, *Sporobolus depauperatus*, *S. pringlei*, *Schedonnardus texanus*, *Agrostis hyemalis*, *Sitanion longifolium*, *S. molle*, *Blepharoneuron tricholepis*, and *Epicampes ligulata*. As would be expected the grass flora here is varied, but the species mentioned, together with the blue grama, are the most important from the stockman's standpoint.

Upon the bottom lands in the southern part of the Territory saccaton (*Sporobolus wrightii*) is without doubt the most important, and it was much more abundant formerly than now. Its place is taken on the saltier bottoms in the Salt, Gila, Little Colorado, and Sulphur Spring valleys by *Sporobolus airoides*.

The bluejoint grasses are of special importance in the southern part of Arizona, and furnish a great deal of the summer feed in the foothills and mountains. They are usually grazed to the ground. The most important species are *Andropogon saccharoides*, *A. contortus*, and *A. hirtiflorus fœnsis*. The first of these often makes a good crop on usually limited highland depressions. The other two are common on rocky hillsides.

There are a number of annuals aside from those noted above which are of much value and often make comparatively large yields on limited areas. Without doubt the most important of these is *Chloris elegans*, which in favorable seasons will sometimes cut a ton of hay to the acre in situations which receive an overflow. It is also an important constituent of the foothills range feed in some localities. It was especially abundant in the Sulphur Spring Valley in 1900, and upon the eastern slope of the Santa Rita Mountains in 1902 and 1903. *Eriochloa punctata* is also an important annual, with about the same habits as the former species, and in the same connection should be mentioned *Eragrostis neo-mexicana*. The triple-awn grass (*Aristida americana*) is abundant in similar situations to the six weeks' grama. While the awns render this of little value after maturity, it nevertheless furnishes some grazing early in the rainy season upon the lower foothills throughout the southern part of the Territory.

Of the perennial species not previously mentioned there is a large number which, although not of great importance in themselves, in the aggregate furnish considerable feed. *Pappophorum wrightii* occurs in places in the open foothills and is of a great deal of importance, and the closely related species *P. vaginatum* is generally found in depressions where water accumulates. In the protection of bushes almost exclusively at the present time is to be found the so-called black grama of this region (*Muhlenbergia porteri*), which is said to have been very plentiful at one time upon open ground. This is a very interesting species, inasmuch as it is one of the few grasses of the region which has perennial culms. Confined as it is to the protection of shrubbery, it, together with a large amount of other vegetation, is left unmolested during the fall, while the grasses on the open ground are grazed off. During the winter, however, this, as well as *Panicum lachnanthum* and other grasses which tend to seek this protection, are grazed off clean, even when they form a tangled mass with cat-claw, mesquite, and cacti. It is very interesting to note that the grasses are not injured by this form of grazing nearly so much as in the open spaces. These protected areas under shrubbery, concerning which considerable has been said during recent years, are often grazed as closely as any other, but the grazing comes after the maturity of the grasses. Vegetation growing in these protected areas has several advantages. The ground is not trampled by stock, and is kept in better condition by the gophers, which almost invariably burrow here. The leaves and twigs of the bushes and joints of the cacti also furnish some protection to them. Upon the sandy bottom *Chætochloa composita* and *Sporobolus strictus* furnish some feed, while *Trichloris fasciculata* makes a thin growth on moist areas and heavier soil. It is the mountain areas that furnish the greatest quantity of valuable feed in southern Arizona. The most important grasses are the perennial gramas, bluejoints, *Leptochloa dubia*, *Lycurus phleoides*, and several species of *Muhlenbergia*. All of these are well mixed and produce a very tall growth, ranging from one-half foot to 3 feet high, but the stand is always very thin, except in the most favorable situations where water and sediment are deposited in the more gently sloping ravines where the steep mountains break off into open foothills.

Upon the sand hills in the valley of the Little Colorado there are several characteristic grasses, of which sand grass (*Calamovilfa longifolia*), drop-seed, (*Sporobolus giganteus*), and *Muhlenbergia pungens* are the most important.

PIGWEED FAMILY.

A large quantity of feed is produced by the different plants which belong to the large natural group of pigweeds. While much of it is browse, there is nevertheless some herbaceous feed furnished by the

common pigweeds, several of which are closely related to the lamb's-quarters.

Without doubt the saltbushes furnish the largest amount of feed in this natural order and are abundantly distributed in many situations, some upon alkaline soil and some upon land with but little or no salt content. In the southern part of Arizona shad scale (*Atriplex canescens*), *A. polycarpa*, *A. lentiformis*, and *A. linearis* are the most abundant of the shrubby species. These are all known to the Mexicans as chamiso. The first is not so prominently a salt-loving plant as the others, although it often occurs upon somewhat alkaline soils. In the Tucson region all but the third of these occur abundantly and are invariably grazed.[a] Shad scale occurs in the valleys throughout the Territory, but the other three mentioned above are of most importance in the alkaline valleys north and west of the Tucson region. They are especially abundant in the valleys of the Gila and Salt rivers and their tributaries. *Atriplex lentiformis* is the most rapidly growing species of this genus with which the writer is familiar. Its remarkable development is well illustrated by observations made in the vicinity of Tempe in 1900, where plants which had sprung up on newly subdued land after the removal of the first crop of wheat were 5½ feet high by the 1st of December. This growth had been made between the month of June and that date.[b] Near Tempe and Phoenix it does not appear to be grazed very much, but upon the ranges along the Gila River it is not uncommon to see canes one-fourth of an inch in diameter grazed off. Having about the same range as the above are two annual species, *Atriplex elegans*, growing almost exclusively upon nonalkaline soil, and the salt-loving species, *A. bracteosa*. Both of these are grazed when feed is scarce. During the past season they were quite closely cropped along the Santa Cruz River south of Tucson. *Atriplex elegans* is a very interesting species in many ways on account of its habit of maturing seed at the close of the winter rainy season and again in midsummer. It therefore, although an annual, lives through the hot dry weather of early summer in the vegetative condition. It should be noted that there are some slight differences between the spring and summer forms, and the collections of the writer, although extensive, fail to show one of the common autumnal fruit forms at all in the spring.

The valley of the Little Colorado is especially noted for its abundance of saltbushes, some of which do not grow elsewhere in the Territory, so far as known. The saltbush flora of this region resembles that of the valley of the Rio Grande in many respects. Here that most valuable species, the spiny saltbush (*Atriplex confertifolia*), so

[a] See Bul. 25, Division of Agrostology, U. S. Department of Agriculture, 1891, Pl. XXVI.

[b] See Pl. IV, fig. 1.

abundant in the Great Basin, is perfectly adapted; and *Atriplex greggii* covers very extensive areas on many of the saline bottoms with an almost pure growth, especially from Corn Creek southeastward through the Holbrook, Adamana, and St. Johns regions. Upon the Navajo and Moqui Reservation, and indeed throughout the valley of the Little Colorado, shad scale fills a very important place upon both mesas and bottom lands. In the petrified forest areas there occurs a shrubby species of *Atriplex* (No. 5085), which appears to be undescribed. This is said to be grazed during the winter. In this same region *Atriplex powelli*, an annual species, covers many areas of washed lands, while *Atriplex expansa* is abundant in some localities.

Next in importance to the saltbushes should be mentioned the white sage (*Eurotia lanata*), which occupies very extensive areas upon the highlands in the northern part of the Territory. It is especially important, as a winter feed only, in the great highland region north and east of the main divide of the San Francisco and contiguous mountains. It is common in places in the higher situations in the southern part of the Territory also, but never abundant enough to be seriously considered in the range ration. It is common in the Sulphur Spring Valley and has been collected upon the Santa Rita Forest Reserve. Greasewood (*Sarcobatus vermiculatus*) makes much winter feed in all the alkaline bottoms of the Gila, Salt, and Little Colorado valleys. Red sage (*Kochia americana*) is abundant enough to furnish some winter feed in the valley of the Little Colorado.

The common lamb's-quarters of the East is represented in Arizona by several species, which are of economic importance. In southern Arizona they are of more importance in the upper foothills than elsewhere, but in the northern higher altitudes they occupy the areas under the junipers upon the mesas and ridges, and sometimes cover large depressions with an almost pure growth. They furnish good summer feed, for sheep and goats especially. The species which grow here are *Chenopodium leptophyllum*, *C. incanum*, *C. fremontii*, and *C. olidum*? (No. 5841). A small annual, *Monolepis nuttalliana*, belonging to this natural group makes a carpet in shallow depressions in the southern part of the Territory during the spring season. This is one of the plants to which the Mexicans apply the name *patota*. It is considered good feed for cattle.

THE CLOVERS.

There are but few situations in Arizona where the clovers are of much importance, but there are suggestions that they may become more abundant as time goes on. In the northern mountains *Trifolium involucratum* and *T. longipes* cover small areas in moist situations. In the canyon bottoms of the southern mountains, which are devoid of meadows in the ordinary acceptance, there grows a species which,

although limited in quantity, makes dense mats over small areas. It is to two small annual species, *Trifolium gracilentum* and *T. tridentatum*, that the greatest interest attaches, for there are indications that these are introduced species which are just beginning to assert themselves in the southern part of Arizona. In March, 1903, there was good feed produced by these species in several localities in the Willow Spring Mountains. Being associated here with alfilerilla and in the direct path of the early sheep migrations from California, it is quite probable that these have been introduced in wool from California and western Great Basin points, where they occur in considerable profusion. It is interesting to note that the maturity of these two species occurs about two months earlier in these mountains than in the Sierra Nevada Mountains east of Fresno, Cal. There is a bare possibility that a systematic effort to distribute these to other mountain ranges, either by securing the seed from the situations where it is produced most abundantly or by systematic herding in the season when the clovers are ripening, may result in establishing them, thereby increasing the feed in the foothills and lower mountains. It is quite certain that they will be of value only in the foothills, below the limit of winter annuals.

ALFILERILLA.[a]

Upon the areas where the alfilerilla is thoroughly established there is no other plant, unless it be Indian wheat, which can compare with it in the quantity of feed which it produces upon the desert mesas for winter and spring grazing. There appears to be no doubt that it was introduced into Arizona by sheep from California points. It is now well distributed as far south as the northern slope of the Santa Catalina Mountains and up the San Pedro Valley as far as Benson. It has not spread very much east of the San Pedro River. From here it extends northward and westward through the desert areas and high into the plateau regions on the north and west sides of the Prescott highlands; thence westward into California. There are scattering plants of it all over the Territory, but it is in the region indicated that it is of importance. It even occurs commonly upon the San Francisco Mountains at an altitude of 7,000 feet, but it is never abundant enough to be of any importance. It is much more abundant in the vicinity of Prescott (5,320 feet), but does not produce as much feed as upon the west side of the Prescott highlands, where it extends up to Iron Springs (6,032 feet). In this region it is well established all the way from Wickenburg (2,067 feet) to Iron Springs, in the edge of the pines. It appears to be perfectly at home in the scrub-oak area below the pines, where it remained green during the season of 1903 as late as the last of May.

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[a] See Plate VI.

According to the opinions of stockmen, it is spreading slowly, and is said to have been first observed near Willow Springs. There is a popular belief that it will thrive only on granitic soils. But this does not account for its peculiar distribution in the Tucson region. Here, as stated above, it makes a good crop in an average year on the northern slope of the Santa Catalina Mountains; but while distributed in scattering individuals all over the Santa Cruz Valley, it is never abundant enough to be of any consequence. There are a few small areas upon the northern slope of the Santa Ritas, where it is as thick upon the ground as it is upon the northern slope of the Santa Catalinas, but these areas are very limited, and therefore do not figure conspicuously in the total feed production. There is a good stand of it upon the east side of the Santa Catalina Mountains, and it is well distributed over the San Pedro Valley as far west as the top of the Rincon Mountains on the Tanque Verde road, but it does not extend in any quantity into the Santa Cruz Valley.

Some systematic attempts have been made to spread the plant. Messrs. Maish & Driscol some years ago sent a force of men to the Canyon del Oro district to gather large quantities of it, to be scattered on their Canoa property. They raked up the plant when the seed was ripening and scattered it upon their land. They have not been able to observe any material benefit. Mr. C. H. Bayless believes that it can be scattered most successfully by systematic herding of sheep at the time that the plant is maturing its seed. His plan is to herd sheep first upon land well seeded, and then upon contiguous unseeded areas. It is thought by those who have observed it that it is gradually spreading southward, and that it will eventually be as abundant in the valley south of Tucson as it is in the Oracle and Willow Springs region now. There certainly appears to be no good reason for holding a contrary view.

MISCELLANEOUS WINTER AND SPRING ANNUALS.

Under the designation "Indian wheat" the rancher recognizes a group of important forage plants belonging to the botanical genus Plantago. There are two important species, both of which make their first appearance in the autumn and mature in the spring. *Plantago fastigiata* occurs mainly upon the mesas and lower areas, and *Plantago ignota* upon the foothills. The mesas in the Tucson and Phoenix region are especially noted for the magnificent growths of *Plantago fastigiata*, which, together with alfilerilla in the latter locality, feeds the largest number of sheep in the Territory during the winter and spring seasons. Next in importance to Indian wheat should be noted patota (*Pectocarya linearis*, *P. setosa*, and *P. pencillata*), the first being much the most abundant, and indeed the only one that need be considered from a forage standpoint. These plants furnish feed up to

the time of ripening, but are of no value after that date, because of their extreme harshness. Belonging to the same family as the latter is a very large group of borages, which are of importance as sheep feed. The most abundant of these are *Plagiobothrys arizonicus*, *P. tenellus*, *Amsinkia tesselata*, *Cryptanthe cylloptera*, *C. intermedia*, *C. angustifolia*, and *Eremocarya micrantha*. The water-leaf family is represented by a large number of very conspicuous plants which are of more or less forage value for a short time. The most numerous of these belong to the genus Phacelia (*Phacelia arizonica*, *P. crenulata*, *P. tanacetifolia*, and *P. ramosa*), which will seem rather peculiar forage plants to many, but they, as well as *Ellisia chrysanthemifolia*, must be listed here as of some forage value, although not grazed except when feed is scarce. Of somewhat more value than the above are numerous plants related to the cultivated phlox, of which the most important are *Linanthus bigelovii*, *L. aurea*, and *Gilia inconspicua* (?). Mexican poppy (*Eschscholtzia mexicana*) is reported by many to be of some value. Mr. Ed. Vail and others assert that their vaqueros report that stock live largely upon this poppy, Indian wheat, and jojoba (*Simondsia californica*), during winter and spring on the west side of the Babuquivari Mountains. The observations of the writer do not entirely confirm these views, but it should be stated that wherever observed other feed has been abundant enough, so that it has not been necessary for stock to graze poppies. *Malvastrum exile* makes a large amount of feed on many of the river bottoms. During the past season it was abundant and extensively grazed in the lower San Pedro, Gila, and Santa Rosa valleys.

The native mustards, *Sophia incisa*, *S. pinnata*, *Lesquerella gordonii*, *Thelypodium lasiophyllum* and pepperwort (*Lepidium lasiocarpum*) form a small but important and interesting group of forage plants in the southern part of Arizona. With the exception of *Lesquerella gordonii* they are not grazed much while green, but after they are ripe the pods and oily seeds are greatly relished, by range horses especially. Horses have never been observed in better condition upon the range than they were upon the mesas south of Tucson in May, 1903. An abundant opportunity was had to observe what they were feeding upon. They appeared to be subsisting entirely upon seeds of these cruciferous plants, which grew mainly in the protection of shrubs, where they are scarcely molested until they are ripe. During the early part of the dry season, however, they were cleaned up about as completely as the grasses in similar situations in autumn.

Quite a number of leguminous annuals are of importance in the southern part of the Territory. Upon the mesas and foothills two species of lotus (*Lotus humistratus* and *L. humilis*) and vetch (*Astragalus nuttallii*) are the most important. A glance at the tables (pp. 26–29) will show the relative importance of these to the other vernal forage

plants upon the northern slope of the Santa Rita Mountains. The lupines are very conspicuous upon the higher mesas and foothills, and are often grazed a little, but they are not relished like the species of lotus. Two species are very common. *Lupinus leptophyllus* often gives its characteristic purple to large areas in steep ravines and hillsides, while *L. concinnus* is fully as abundant in places.

Miscellaneous species such as *Baeria gracilis* and *Baileya multiradiata* are abundant enough to impart their characteristic golden color to the landscape at times. *Calyptridium monandrum* and *Sphærostigma chamænerioides* both contribute to the forage ration. The two first mentioned in this paragraph are composites, and are grazed by horses, especially when they are in bloom. Very little aside from the heads is eaten. *Chænactis stevioides*, another composite annual, is much more abundant in many places than these, but it is seldom eaten. In the spring of 1903 cattle in the vicinity of Santa Rosa, where the country was white with it, were grazing upon it a little. Mr. Charles Howard, of Ashfork, reports that his flocks subsist for weeks upon *Gymnolomia annua*, which is a particularly conspicuous thing upon these highlands.

MISCELLANEOUS BROWSE PLANTS.

Besides the saltbushes and their relatives, the majority of which are browse plants, a large number of other shrubs furnish feed for stock. These plants are especially valuable during the two seasons of short feed. The value of the mesquite is proverbial, on account of the large quantity of beans which it furnishes for winter and fall feed; but it is also grazed during the summer dry season. The cat-claw (*Acacia greggii*) and *Acacia constricta* are second in importance only to the mesquite as browse plants, but their fruit is of practically no value to stock. The twigs of the blue palo verde (*Parkinsonia torreyana*) and bigota (*P. aculeata*) also make winter feed of considerable importance. Jojoba (*Simondsia californica*), abundant in the foothills and lower mountain areas, appears to be the most important browse plant in these situations. The central foreground of Plate VI, figure 1, shows how this shrub, which is normally 4 or more feet high, was grazed during the past season near Dudleyville. Mr. Ed. Vail reports this one of the most important browse plants in the valleys west of the Babuquivari Mountains. *Eriogonum microthecum* and *Calliandra eriophylla* are also of much importance in the higher foothills and lower mountains. There are large areas on the east and southeast of the Huachuca Mountains, where the first has practically taken possession. It appears to spread with excessive grazing in this locality, and it is therefore very fortunate that it is of some forage value. These shrubs are especially characteristic of the southern regions.

The scrub live oaks of the entire Territory of Arizona form a class

by themselves, and deserve more attention as forage plants than is usually accorded them. White oak (*Quercus arizonicus*) is probably the most important species in the southern part of Arizona, where it has even been known to be cut and fed to cattle. The black oak (*Quercus emoryi*) is said not to be touched by cattle, a statement which it has not been possible to verify. *Quercus turbinella* furnishes more feed in places in the Prescott and Bradshaw mountains than all other forage plants combined, goats and even sheep having little else to eat at some seasons.

Brigham's tea (*Ephedra trifurca*, *E. nevadensis*, and *E. torreyana*) is very commonly grazed. The first species is confined to southern Arizona mesas and foothills, while the other two are most common in the central and northern portions of the Territory. The three-leaved sumacs (*Rhus trilobata* and *R. emoryi*) are commonly browsed. Upon the highlands of the central portion of the Territory *Cowania mexicana* and *Fallugia paradoxa* are grazed wherever found. Upon the mesas and foothills in the Tucson region there are two species of composite shrubs, *Baccharis brachyphylla* and *B. bigelovii*, which are invariably grazed.

Upon all the sandy ridges in the valley of the Little Colorado there is more or less sage (*Artemisia filifolia*), which is said to make valuable winter feed.

HAY CROPS.

No more than a very brief mention of the cultivated forage crops is necessary here. Alfalfa is of course the staple wherever water for irrigation is obtainable, and there is no region where more profitable returns are obtained than in the river valleys of the Territory. It is a common practice to cut a crop of barley with the first crop of hay each year upon poorly established meadows; but strange as it may seem, the bearded variety is usually sown, although the objectionable feature of this could be very easily dispensed with by sowing the beardless form instead. It is a common practice where alfalfa meadows are pastured to cut the first crop, for two purposes. One is to get rid of the weeds and the other is to give the plants a chance to recuperate from the close pasturage by this season of growth.

Barley and wheat are very largely grown for hay as winter crops, and are frequently sown for pasturage also. The Mexican population cut a large amount of this winter grain crop, bind it up in small sheaves 6 to 10 inches in diameter, and sell it in the green state in the cities and mining camps, where there is a small market for this class of roughage. These sheaves sell at the rate of about 20 for 25 cents. Sorghum is commonly grown in the summer rainy season, supplemented by light irrigations, upon the lands which produce the winter crop of barley.

Mention has been made in previous pages of the use of *Bouteloua rothrockii* as a hay plant, but with it are always cut a large variety of other species, a specific mention of which is not necessary. Sometimes saccaton (*Sporobolus wrightii*) is cut, along with such other species as grow upon the lowlands. Upon the east side of the Santa Rita Mountains blue grama (*Bouteloua oligostachya*) and bluejoint (*Andropogon saccharoides*) together with *Chloris elegans*, often make a small crop of hay. In many situations Johnson grass makes an important addition to the native hay plants upon overflowed areas.

The Mexican population makes use of a number of weedy plants, the most important of which is *Amaranthus palmeri*. In the vicinity of Tumacacori and Sopori during the past season there were large quantities of this plant put up for winter use. The crop was invariably obtained upon land from which a crop of barley had been removed in the late spring or early summer. The barley crop in this region is often the only one grown. The lands therefore lie idle from May to October, when they are plowed again for the fall seeding. During the summer they furnish some weedy pasturage, and from favorable situations a large volunteer crop of this weed is obtained. Plate VIII, figure 1, shows Mexicans stacking a large volunteer crop of this plant about the 1st of October. The yield was not far from 3 tons per acre in the field which was being harvested. These men report it to be good hay for horses, but rather poor for cattle.

WEEDS.

In a region of such small production it is not to be expected that weeds have a very detrimental influence upon native pasture lands. The weeds, as a general rule, furnish feed when other things fail. The use that is made of alfilerilla is a striking example of this.

In a few instances, however, absolutely worthless weeds flourish upon the most productive of the range lands. The alluvial bottoms which were once covered with either annual or perennial grasses have suffered great injury during recent years on account of the establishment of the cockle bur (*Xanthium canadense*). Hundreds of acres of the very best and most productive lands in the higher valleys of southern Arizona have been absolutely taken possession of by this plant during recent years. It is hoped that Johnson grass will be the means of reclaiming these areas. It is the only plant known which can compete successfully with this weed.

Along the main line of the Santa Fe Railway, for a distance of 20 or more miles on each side of the road, the Russian thistle is well established. In the valley of the Little Colorado it appears to be quite at home upon the dry mesa land, and will doubtless become more conspicuous as time goes on. While it will cause trouble upon the cultivated areas, it is not thought that it will ever injure the range

lands; indeed, it may be a decided benefit. So far as known, it does not occur in the southern part of Arizona at all.

Cleome serrata has become very conspicuous upon the poorly grassed areas of overflowed depressions throughout the northern highlands. By some this plant is said to be relished by sheep, but evidences of this have not been seen. It is especially abundant in the vicinity of Flagstaff and upon the northern slope of the White Mountains.

In the southern portion of Arizona there are two perennial weeds related to the golden rods which it is claimed are spreading rapidly. These are *Isocoma coronopifolia* and *Gutierrezia microcephala*. They are very abundant in portions of the Santa Cruz and Altar valleys.

Upon the cultivated meadows the squirrel-tail grass is very troublesome and unsightly in irrigated districts. In pastures, however, it is of little or no detriment, for it is usually prevented from becoming conspicuous by the close grazing which is usually practiced upon the alfalfa pastures. It is interesting to note that in the Salt and Gila valleys *Hordeum murinum* is the prevalent species, while *H. jubatum*, which has such a bad record in the Plains region, has not been observed. In the valley of the Little Colorado, however, this species is nearly if not quite absent, while *Hordeum jubatum* is very common and even troublesome in the cultivated fields.

PLANTS INJURIOUS TO STOCK.

There are times during years of short feed when the creosote bush (*Covillea tridentata*) causes a good deal of injury to sheep. No stock of any kind eat this shrub ordinarily, but when feed is scarce sheep are sometimes forced to feed upon it. According to a recent report from Mr. E. S. Gosney, of Flagstaff, the animals, after feeding upon this shrub for a time, run about in an unsteady fashion, and are very likely to run into any obstacle which happens to be in their way. They are said to very often run toward the herder, or even his dogs, as though seeking protection. Mr. W. H. Campbell, also of Flagstaff, who has had a good deal of experience upon the deserts north of Phoenix, states that the greatest mortality occurs among pregnant ewes.

Upon the San Francisco and contiguous highlands there occurs a great deal of loco (*Aragallus lambertii*), and in some cases in the same region areas are said to have been abandoned as sheep grazing grounds on account of the preponderance of *Asclepiodora decumbens*.

Mechanical injury is sometimes done by six weeks' grass (*Bouteloua aristidoides*) and triple-awned grass (*Aristida americana*). When matured the seeds of these two species are very annoying, to say the least, to both men and animals. The sharp-pointed seeds work into both the fleece and the feet of sheep, but are more especially injurious to the latter. They accumulate between the hoofs of the animals to

such an extent as to disable them. The areas of these grasses are avoided during the time of their ripening until the seed has fallen off and partially disappeared into the soil.

SUMMARY.

The carrying capacity of the lands in Arizona varies from the rate of one bovine animal to 50 acres to one to 100 acres.

Johnson grass appears to be the best adapted for preventing erosion, and will thrive in favorable situations which receive two or more irrigations by flood waters during the year. Bermuda grass does not appear to be promising without irrigation.

The valley of the Little Colorado, so far as much of its vegetation is concerned, resembles the valley of the Rio Grande, but the yield of feed is very much smaller.

From the stockman's point of view, the seasons upon the lower southern areas are four in number, each differing from the others in the character of the feed which is available. The two seasons of feed production alternate with two seasons of short feed.

(1) Middle of February to middle of April or first of May, characterized by a growth of annual weedy plants, which furnish feed for a short time.

(2) First of May to middle of July or first of August, having little growth except of shrubby plants, upon which stock largely subsist.

(3) Middle of July to first of December, which is the season of the best feed, being characterized by growth of perennial grasses and many other forage plants.

(4) First of December to middle of February, which is the hardest season of the year upon all stock.

The growth of winter and spring annuals occurs mainly below an altitude of 4,000 feet. The best pasture lands are located principally above an altitude of 3,000 feet.

In southern Arizona a large part of the feed upon the lower unoccupied lands is furnished by shrubby plants. The remainder of the feed upon these areas, as well as upon the mesas below 3,000 or 3,500 feet, is furnished by annual weedy plants in the spring, together with annual and a few perennial grasses in the summer, and in the higher foothills and mountains by perennial grasses.

Goat raising is on the increase, and it is believed that this industry will continue to develop.

The total annual precipitation can not serve as an index of the character of the feed upon the range, its distribution during the hot summer season being of paramount importance.

It is common for cattle to travel 10 miles from water to feeding grounds, and sheep are often herded 6 miles away, making a total

travel between waterings of 20 miles for cattle and 12 miles for sheep. Horses travel a much greater distance.

The prairie dog is doing a large amount of damage in the north and northeastern portions of the Territory.

Beardless barley should be more extensively substituted for the bearded form for supplementing the first cutting of alfalfa.

The Russian thistle, while widely distributed in the northern part of Arizona, has not yet appeared in the southern part to any extent at least.

There appears to be abundant evidence that the creosote bush is injurious to sheep, which are sometimes forced to eat it on account of a scarcity of feed.

The average total available feed which it is practicable to utilize upon the large inclosure is believed to be between 150 and 200 pounds of air-dry substance per acre.

Alfilerilla, one of the most important forage plants of the Territory, which was probably introduced from California in the wool of sheep, is spreading. It is believed that two species of clover were introduced in the same way.

Experimental work carried on thus far in attempting to introduce perennial forage plants upon the mesas has given very little encouragement. *Panicum texanum*, an annual, has given the best results of anything thus far introduced, and it is believed that more success will be secured with annuals than with perennials. They are not as good feed, but short-lived plants with good seed habits now furnish the main feed upon the mesas.

The following tabulation showing the relative weight of desert annuals and certain of their reproductive portions will be of interest in this connection:

Plant.	Number of plants.	Fruit or seed.	Weight of seed or fruit.	Weight of plant less seed or fruit	Condition of plants.
			Grains.	*Grains.*	
Pectocarya linearis	2	Seed	15½	20	Fully mature.
Lotus humilis	1	Pods	19	12	Half of pods mature.
Monolepis nuttalliana	1	Seed	49	40	10 per cent of seed not mature.

This table shows, so far as this amount of data can show, that the seed production of these three characteristic desert annuals is large when compared with the total weight of the plants. *Lotus humilis* produced, in the condition indicated, 7 grains of clean seed. Two plants of *Bouteloua aristidoides*, weighing 48 grains, produced 27 grains of spikelets. It is believed that there is a suggestion here regarding the nature of the plants which will be most successful upon

these arid mesa lands. Alfilerilla is already widely introduced. It has good seed habits and special provision for burying its seed. Of course perennial forage plants would furnish better feed than the annuals, but there is little hope of establishing them without greater expense than the economic benefit seems to warrant. It may be possible to establish some of the hardier perennial species upon the foothills. This, however, is a matter for experimental work to determine.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) Laosa, a typical southern Arizona ranch.

PLATE II. Contrast between dry and wet seasons in foothills range. Fig. 1.—Live-oak belt, upper foothills, eastern slope of Huachuca Mountains, July 1, 1903, before the rainy season began. Last year's crop of grass has all been eaten off. Fig. 2.—Upper foothills, northern slope, Santa Rita Mountains, just below the oak belt, showing *Panicum lachnanthum*, grama, and mesquite at the close of the rainy season.

PLATE III. The large inclosure. Fig. 1.—Pyramid Hill, section 18, township 18, range 15. Horses digging for water in the sands of an arroyo. September, 1902. Fig. 2.—Looking south from the top of Pyramid Hill, showing the general character of the fenced area. October, 1902.

PLATE IV. Saltbushes. Fig. 1.—*Atriplex lentiformis*, the largest of our native saltbushes. Tempe, Ariz., November, 1902. Fig. 2.—*Atriplex elegans* in large inclosure, northern foothills, Santa Rita Mountains, September, 1903.

PLATE V. Fig. 1.—Hay meadow, Salt River Valley. First crop of alfalfa with winter barley, which greatly increases the yield. Phoenix, April, 1903. Fig. 2.—Erosion along Pantano Wash, east of Santa Rita Mountains, October, 1902.

PLATE VI. Alfilerilla range. Fig. 1.—Alfilerilla and Indian wheat near Dudleyville. In the central foreground are shown closely grazed bushes of "jojoba" (*Simondsia californica*). Fig. 2.—Alfilerilla and Indian wheat near Oracle. *Opuntia engelmanni*, *Yucca radiosa*, and mesquite are the conspicuous plants.

PLATE VII. Two phases of the range question. Fig. 1.—Goats and the oak brush upon which they live. Mayer, September, 1903. Fig. 2.—The remains of thirteen head of cattle in a space of 30 feet along a small arroyo near Arivaca, as the result of too great distance between feed and water. April, 1903.

PLATE VIII. Haying scenes in southern Arizona. Fig. 1.—Mexicans at Sopori stacking "celite" (*Amaranthus palmeri*), which makes a large volunteer crop after the winter crop of grain hay has been removed. October, 1903. Fig. 2.—A Mexican packing hay from the mountains. Santa Rita Mountains, July, 1903.

PLATE IX. Native pasture lands in southern Arizona. Fig. 1.—Galleta (*Hilaria mutica*) in a swale south of Vail Station. September, 1902. Old grass, there being practically no growth this year. Fig. 2.—A round-up in the northern foothills of the Santa Rita Mountains, April, 1903, when the large area was being inclosed.

PLATE X. Fig. 1.—An ocotilla forest about 4 miles northeast of the large inclosure. September, 1902. Practically no feed is produced here. Fig. 2.—The work of prairie dogs upon the northern slope of the White Mountains. Large areas of grass are destroyed by these animals. July, 1903.

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FIG. 1.—LIVE-OAK BELT, UPPER FOOTHILLS, EASTERN SLOPE OF HUACHUCA MOUNTAINS, FIRST OF JULY, 1903, BEFORE THE RAINY SEASON BEGAN; LAST YEAR'S CROP OF GRASS ALL EATEN OFF.

FIG. 2.—UPPER FOOTHILLS, NORTHERN SLOPE, SANTA RITA MOUNTAINS, JUST BELOW THE OAK BELT, SHOWING PANICUM MACHNANTHUM, GRAMA, AND MESQUITE AT THE CLOSE OF THE RAINY SEASON.

CONTRAST BETWEEN DRY AND WET SEASONS IN FOOTHILLS RANGE.

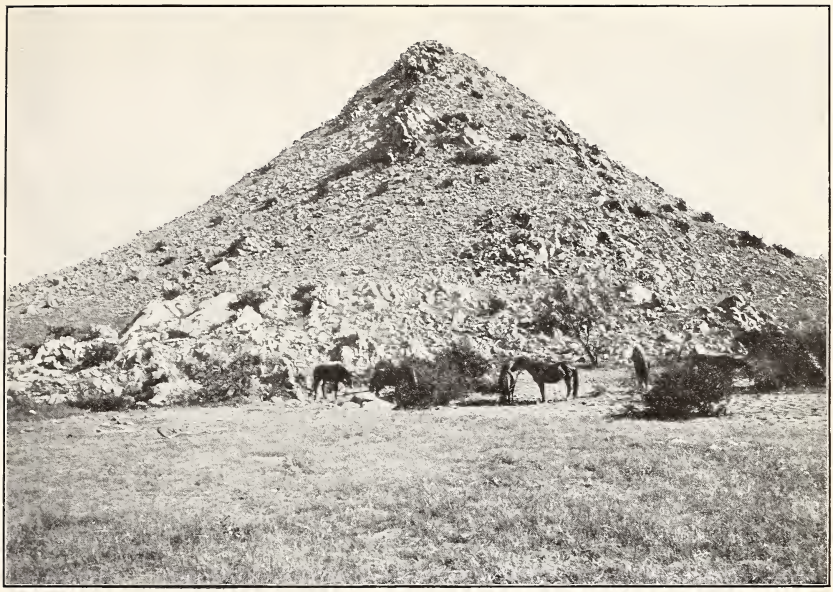

FIG. 1.—PYRAMID HILL, SEC. 18, T. 18, R. 15. HORSES DIGGING FOR WATER IN THE SANDS OF AN ARROYO, SEPTEMBER, 1902.

FIG. 2.—LOOKING SOUTH FROM THE TOP OF PYRAMID HILL, SHOWING GENERAL CHARACTER OF FENCED AREA, OCTOBER, 1902.

THE LARGE INCLOSURE.

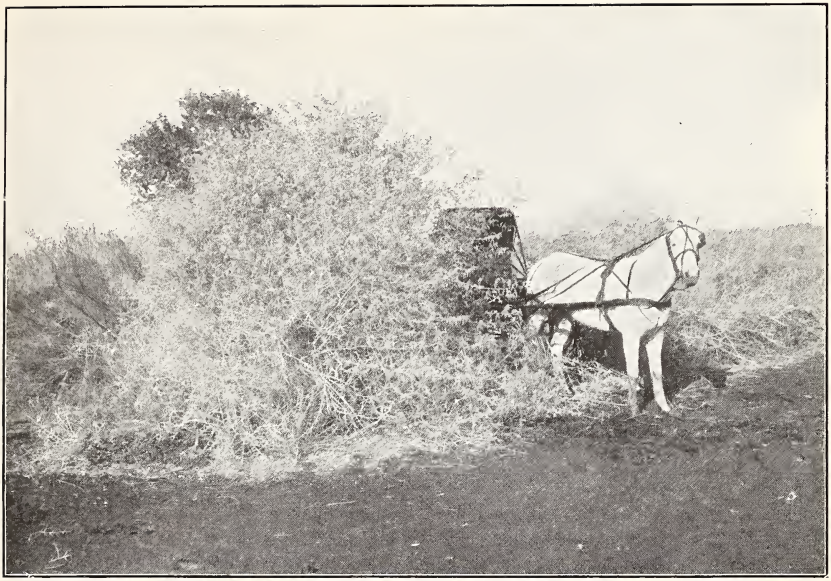

FIG. 1.—ATRIPLEX LENTIFORMIS, THE LARGEST OF OUR NATIVE SALTBUSHES, TEMPE, ARIZ., NOVEMBER, 1902.

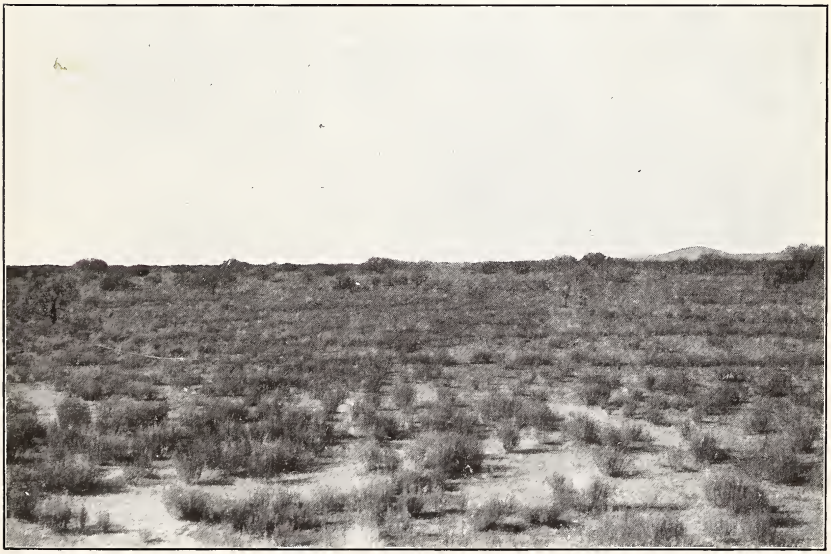

FIG. 2.—ATRIPLEX ELEGANS. LARGE INCLOSURE, NORTHERN FOOTHILLS, SANTA RITA MOUNTAINS, SEPTEMBER, 1903.

SALTBUSHES.

FIG. 1.—HAY MEADOW, SALT RIVER VALLEY. FIRST CROP OF ALFALFA WITH WINTER BARLEY, WHICH GREATLY INCREASES THE YIELD. PHOENIX, APRIL, 1903.

FIG. 2.—EROSION ALONG PANTANO WASH, EAST OF SANTA RITA MOUNTAINS, OCTOBER, 1902.

FIG. 1.—ALFILERILLA AND INDIAN WHEAT NEAR DUDLEYVILLE. IN THE CENTRAL FOREGROUND IS SHOWN CLOSELY GRAZED BUSHES OF "JOJOBA" (SIMONDSIA CALIFORNICA).

FIG. 2.—ALFILERILLA AND INDIAN WHEAT NEAR ORACLE. OPUNTIA ENGELMANNI, YUCCA RADIOSA, AND MESQUITE (PROSOPIS VELUTINA) ARE THE CONSPICUOUS PLANTS.

ALFILERILLA RANGE.

FIG. 1.—GOATS AND THE OAK BRUSH UPON WHICH THEY LIVE, MAYER, ARIZ., SEPTEMBER, 1903.

FIG. 2.—THE REMAINS OF 13 HEAD OF CATTLE IN A SPACE OF 30 FEET ALONG A SMALL ARROYO NEAR ARIVACA, THE RESULT OF TOO GREAT DISTANCE BETWEEN FEED AND WATER. APRIL, 1903.

TWO PHASES OF THE RANGE QUESTION.

FIG. 1.—MEXICANS AT SOPORI STACKING "CELITE" (AMARANTHUS PALMERI), WHICH MAKES A LARGE VOLUNTEER CROP AFTER THE WINTER CROP OF GRAIN HAY HAS BEEN REMOVED. OCTOBER, 1903.

FIG. 2.—A MEXICAN PACKING HAY FROM THE MOUNTAINS, SANTA RITA MOUNTAINS, JULY, 1903.

HAYING SCENES IN SOUTHERN ARIZONA.

FIG. 1.—GALLETA (HILARIA MUTICA) IN A SWALE SOUTH OF VAIL STATION, SEPTEMBER, 1902. OLD GRASS, THERE BEING PRACTICALLY NO GROWTH.

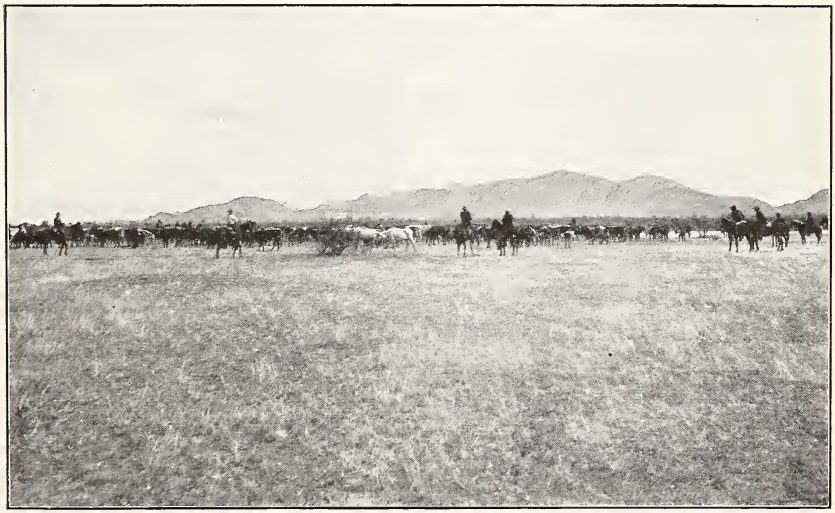

FIG. 2.—A ROUND-UP IN THE NORTHERN FOOTHILLS OF THE SANTA RITA MOUNTAINS, APRIL, 1903, WHEN THE LARGE AREA WAS BEING INCLOSED.

NATIVE PASTURE LANDS IN SOUTHERN ARIZONA.

FIG. 1.—AN OCOTILLA FOREST ABOUT 4 MILES NORTHEAST OF THE LARGE INCLOSURE, SEPTEMBER, 1902. PRACTICALLY NO FEED PRODUCED HERE.

FIG. 2.—THE WORK OF PRAIRIE DOGS UPON THE NORTHERN SLOPE OF THE WHITE MOUNTAINS, JULY, 1903. LARGE AREAS OF GRASS LANDS ARE DESTROYED BY THIS ANIMAL.